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ON THE OCCURRENCE OF *CALLUMBONELLA SUTURALIS* (PHILIPPI, 1836) (MOLLUSCA: GASTROPODA: PROSOBRANCHIA) ON THE SOUTH ATLANTIC COASTS OF EUROPE

‡MANUEL ANTÓNIO E. MALAQUIAS[1&2], JOSÉ PEDRO BORGES[2] & TERESA C. BORGES[1]

Abstract The present paper reports the occurrence of the gastropod Callumbonella suturalis *(Philippi, 1836) on the south of Portugal and confirms the distribution of this species on the south Atlantic coasts of Europe. In spite of being fairly common off the NW coast of Africa and in the western Mediterranean Sea, the species seems to be rare in Europe, with very scarce records, particularly in the recent times. It is a deep-water species, the known bathymetric distribution ranging from 160 to 2324 m, occurring on mud, fine sand, silt and clay silt bottoms.*

Key words Callumbonella suturalis, *Biogeography, Taxonomy, Ecology, Europe*

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INTRODUCTION

The prosobranch mollusc *Callumbonella suturalis* (Philippi, 1836) was originally described from a fossil shell collected in Sciacca, Sicily, Italy (Philippi, 1836; 1844). The first notice and description of live specimens was given by Jeffreys (1873; 1883) when working on specimens dredged from between 455 and 1595 meters during the "Porcupine" expedition in 1869 and 1870. This author reports the occurrence of the species from several localities in northern Europe, including points as far north as the southern Irish and British coasts. On the Iberian Peninsula he reported the species from Vigo, Spain, to off Sagres in south-west Portugal. Jeffreys also reports the species from the western Mediterranean coast of North Africa in the Gulf of Tunis, Algeria and Morocco.

Locard (1898), working on samples from the "Travailleur" and "Talisman" expeditions adds new locations to the geographical distribution of this species, reporting it in the Atlantic off the west coast of Portugal, Morocco and Sahara and in the Mediterranean; the Gulf of Marseille, west of Corsica, north of Oran and the east coast of Spain, at depths of between 160 and 2324 meters.

Dautzenberg (1891; 1927) and Dautzenberg & Fischer (1897) studying the samples collected during the Atlantic Ocean expeditions carried out by Prince Albert I from Monaco reports the occurrence of this species in the Gulf of Gascony, off the NW coast of Spain, Gibraltar and south of Portugal, at depths of between 160 and 749 meters in fine sand, silt and clay silt bottoms.

Ghisotti & Mellone (1971) refer it to be predominantly a deep-water Atlantic species, reporting it also from the Mediterranean up to the Sicily Channel. Those authors remark that the Mediterranean specimens are usually larger in size. Nordsieck & Talavera (1979) add the Canary Islands to the known geographical distribution of the species reporting its occurrence in the Gran Canaria Island. Marin & Ros (1990) refer the occurrence of the species off Cape Tiñoso in the southeast of Spain (Alicante and Murcia coasts) referring to specimens collected by commercial fishing boats over silt bottoms at depths of more than 200 meters.

Poppe & Goto (1991) consider the species as common along the NW coast of Africa

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[1] Centro de Ciências do Mar, Faculdade de Ciências do Mar e do Ambiente, Universidade do Algarve, Campus de Gambelas, 8000-817 Faro, Portugal mmalaqui@ualg.pt

‡Present address: Department of Zoology, The Natural History Museum, Cromwell Road SW7 5BD, London, U.K. manm@nhm.ac.uk

[2] Instituto Português de Malacologia, Zoomarine, E. N. 125, Km 65, Guia 8200-864 Albufeira, Portugal josepedroborges@hotmail.com

reporting it off the Canary Islands between 230 and 2300 meters deep. They refer to the species as being rare in the European waters. According to their opinion the occurrence of the species in the Alboran Sea requires confirmation, since the specimens from Mellila could actually have been fished on the Atlantic coast of Morocco near Larache.

Martinez *et al.* (1993), as a result of the scientific campaign "CAP-89" referred to two specimens collected off the Cantabrian Sea, Asturias (north of Spain) and Templado *et al.* (1993), during the scientific campaign "Fauna I", collected a few specimens in the Spanish Mediterranean and also in the Atlantic waters of the Gulf of Huelva.

We can also find this species cited in literature under other generic and specific names (see Specimen Description). Specimens from Cape Verde Archipelago, which seems to be the southern limit of the geographical distribution, were named *Gibbula gorgonarum* Fischer, 1883 (Fischer, 1883; Locard, 1898; Dautzenberg & Fischer, 1906; Nobre, 1909; Nordsieck, 1968). The species *Trochus folini* Fischer, 1882 according to Jeffreys (1883), Ghisotti & Mellone (1971) and Poppe & Goto (1991), is just a large form of *C. suturalle* coming from the Mediterranean. *Trochus (Margarita) tetragonostoma* Jordan, 1895 is also regarded as a synonym of *C. suturale*. The description of this species was made from a single immature specimen (3 by 3 mm), from the Faroe Channel, which the author considered similar to *C. suturale* (Jordan, 1895). A particular case seems to be the name *Calliostoma vicentae*, a species named by Dr. Juan Rutlant, but never formally reported. This name was used by shell-dealers and had been synonymized by Poppe & Goto (1991) with *Callumbonella suturalis*. A detailed analysis of this problem can be found in Rosenberg & Petit (2002).

Despite the existence of many records for this species in the Atlantic coasts of Europe,

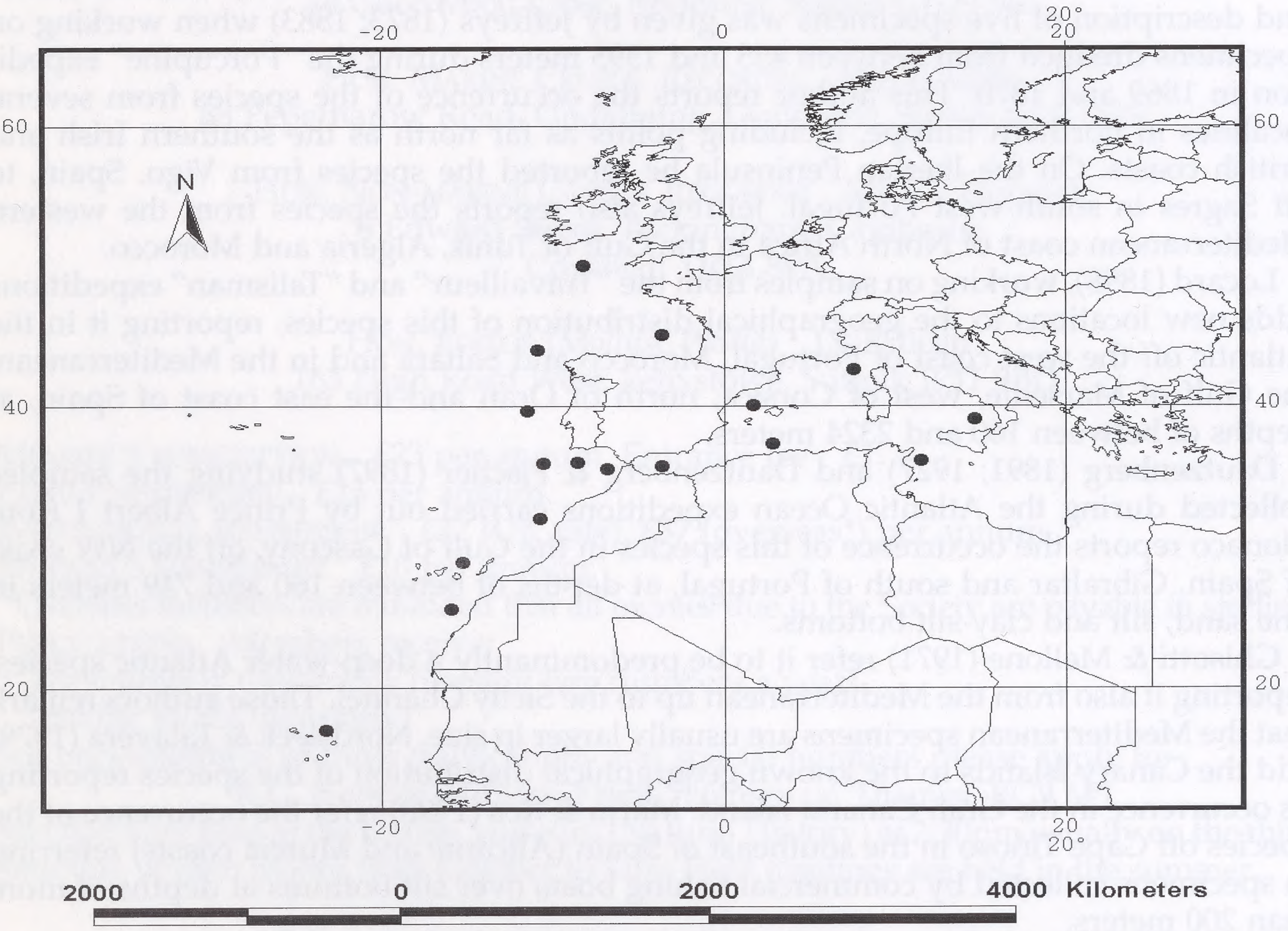

Figure 1 Geographical distribution of *Callumbonella suturalis* (Philippi, 1836).

recent citations are very scarce. The present paper reports three very recent occurrences of *Callumbonella suturalis* in the south of Portugal and confirms the distribution of this species in the south Atlantic coasts of Europe.

METHODOLOGY

During June and September of 1999, as a result of the European project DISCALD initiated by the University of the Algarve (Portugal), a study of the discards and by-catches of the Portuguese fisheries on the south coast of Portugal, two well-preserved shells of the gastropod mollusc *Callumbonella suturalis* (Philippi, 1836) were collected. More recently a third specimen was also collected.

Studied material: one shell, 11.3 mm high and 13.2 mm in diameter, collected on 10th July 1999 at a depth of between 449 and 484 meters, on muddy bottom, by a crustacean trawler on the Algarve coast (36º50'20"N - 8º02'36"W). This specimen is in the collections of the "Museo Nacional de Ciencias Naturales" of Madrid, Spain with the catalogue reference MNCN15.05/45911. One shell, 11.7 mm high and 14.4 mm diameter, collected on 7th September 1999 at a depth of between 472 and 624 meters, on muddy bottom, by a crustacean trawler on the Algarve coast (36º 48' 30"N – 8º 00' 36"W); one shell, 12.5 mm high and 13.9 mm in diameter collected on May 2002 at a depth of 366 meters, on muddy bottom, by a crustacean trawler on the Algarve coast off Olhão. This specimen is in the collections of the "Museo Nacional de Ciencias Naturales" of Madrid, Spain with the catalogue reference MNCN15.05/46611.

DESCRIPTION

Callumbonella suturalis (Philippi, 1836)

Trochus suturalis Philippi, 1836 (*En. Moll. Sici.*, vol. **I**: 185, t. x. f. 23, 23a)
Zizyphinus folini Fischer, 1882 (*J. Conchy.*, **12**(1): 50)
Gibbula gorgonarum Fischer, 1883 (*J. Conchy.*, **13**(4): 393)
Trochus (Margarita) tetragonostoma Jordan, 1895 (*Proc. Malac, Soc. London,* **1**(6): 265)
"Calliostoma vicentae Rutlant" unavailable manuscript name

Measurements 12.5 mm high and 13.9 mm in diameter.

Description Shell conical, creamy flesh coloured with some pink tonality. Protoconch eroded. Teleoconch with 6 slightly convex whorls and a thin but well marked suture. Sculpture consisting of thin granulose concentric cords, more evident near the suture. The middle cords are absent in the first whorls. Body whorl angled at the base and with prosocline growth striae. Base convex with thin irregular smooth cords. Umbilicus covered by a white callous. Aperture squared, prosocline. Columella smooth.

DISCUSSION

The last reliable records of specimens of *Callumbonella suturalis* (Philippi, 1836) collected along the European Atlantic coasts are those of Dautzenberg (1927), Martinez *et al.* (1993) and Templado *et al.* (1993). The first author refers to material dredged during

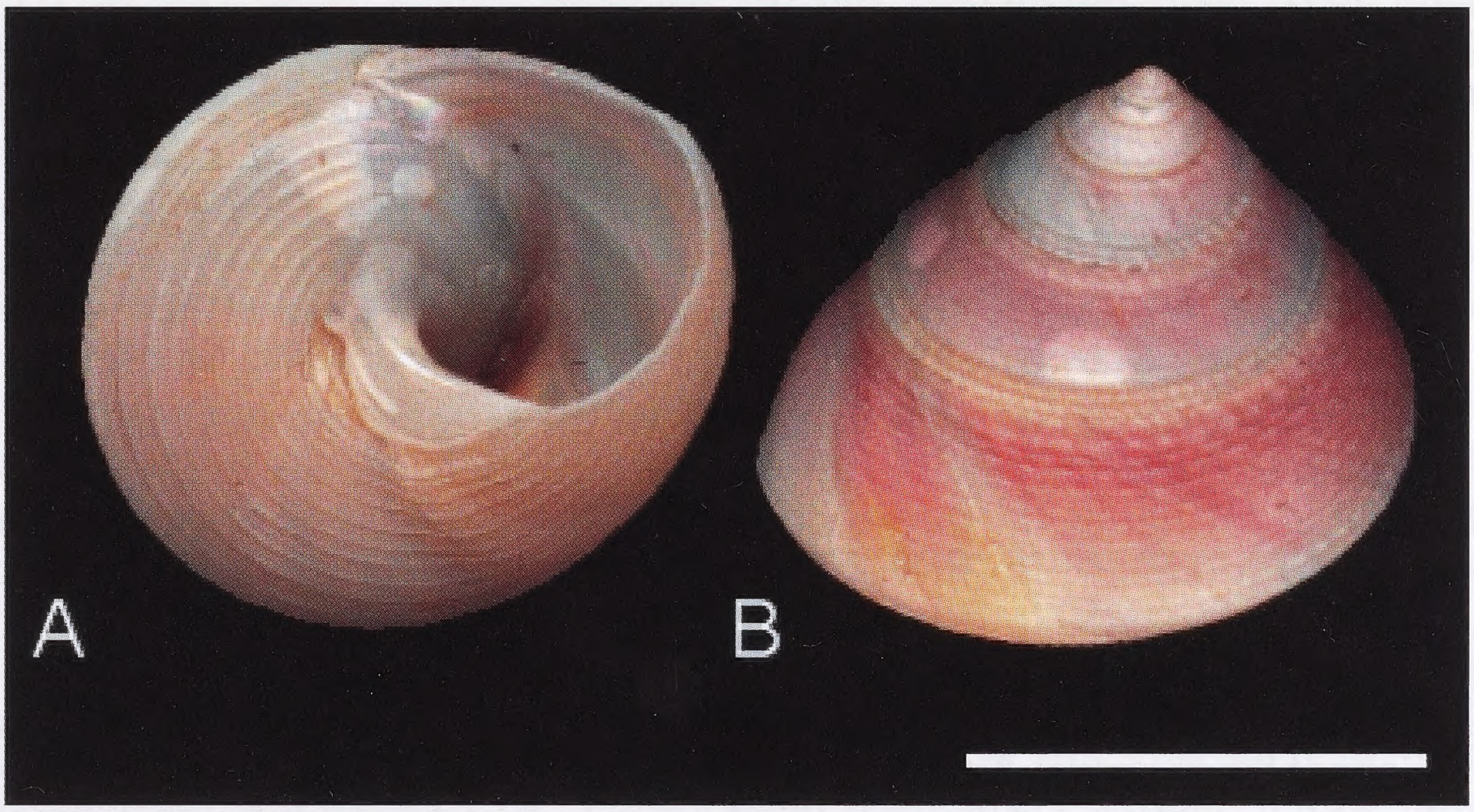

Figure 2 *Callumbonella suturalis* (Philippi, 1836): a – ventral view and b – dorsal view of the shell. (MNCN15.05/46611) (scale bar = 10mm).

the Scientific Expedition accomplished by the Prince Albert I from Monaco in the year 1908, dredged south of Portugal (36°42′N – 8°40′30″W), between 310 and 749 meters deep. Martínez *et al.* (1993) referred to two specimens collected at depths of between 664 and 724 m, off the Cantabrian Sea, Asturias (north of Spain) and Templado *et al.* (1993) reported the species from the Gulf of Huelva (36° 33′ 94″N – 33° 36′ 66″N and 07° 06′ 50″W – 07° 05′ 90″W), between 500–504 meters deep in muddy bottoms.

Biogeographically, this is an Atlantic-Mediterranean species, with affinity to the Mauritanian area and to the west Mediterranean coast of Africa. The geographic distribution limits seem to be the south of the British Isles in the north, the Canary Islands in the west, the Gulf of Tunis in the east and the Cape Verde Archipelago in the south.

Ecologically, the species has a deep-water habitat, ranging in known bathymetric distribution from depths of between 160 and 2324 meters and occurring in mud, fine sands, silt and clay silt bottoms. Compared with specimens from Morocco the Portuguese shells are smaller in size, more angled at the base and with more granulose cords.

ACKNOWLEDGEMENTS

Thanks are due to the scientific staff of the research group "BIOPESCAS" from the University of the Algarve. This work was sponsored by the project DISCALG (Study Project No. 97/0087 – European Commission, Directorate General Fisheries).

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PHYSELLA (COSTATELLA) ACUTA DRAPARNAUD IN BRITAIN AND IRELAND — ITS TAXONOMY, ORIGINS AND RELATIONSHIPS TO OTHER INTRODUCED PHYSIDAE

ROY ANDERSON[1]

Abstract The freshwater pulmonate family Physidae is represented in Britain and Ireland by two naturally occurring species, Aplexa hypnorum *(L.) and* Physa (Physa) fontinalis *(L.).* Physella (Physella) gyrina *(Say), a species native to North America, has recently been reported from Lough Neagh in Ireland and there are earlier records for western Britain (Anderson 1996). Another putative North American species,* Physella (Costatella) acuta *(Draparnaud), is widespread in Britain and is reported also for the first time from Ireland. Unlike* gyrina*, the home range of* acuta *in North America is unknown and there is confusion about its identity there. A case is made for synonymising* Physella heterostropha *(Say), native to the eastern and south-eastern US, with* P. acuta*. The current state of taxonomy in the subfamily Physinae is briefly discussed.*

Key words Physa fontinalis, Physella acuta, Physella heterostropha, *non-native pulmonates, origins, relationship, taxonomy*

INTRODUCTION

The freshwater pulmonate family Physidae is represented in Britain and Ireland by two naturally occurring species, *Aplexa hypnorum* (L.) and *Physa (Physa) fontinalis* (L.). Both are widespread in suitable habitats, in the case of *Aplexa* temporary water-bodies such as ditches and marshes, and in the case of *P. fontinalis* clear, macrophyte-dominated water in lakes and slow streams (Kerney 1999). The North American *Physella (Physella) gyrina* (Say) has recently been discovered in Loughs Neagh (Anderson 1996) and Eske (Anderson 2002) in Ireland and before this was known from a few sites in south-west England and Wales (Dean 1920; Ellis 1969; Kerney 1976). A fourth species, *Physella (Costatella) acuta* Draparnaud, has been recorded widely in Britain (Kerney 1976) and though introduced to Britain at a late date has been regarded as a native in continental Europe (Germain 1930), though this point is now in dispute. Like *P. gyrina, Physella acuta* has been expanding its range in the British Isles and is reported for the first time from Ireland in this paper.

The identities of the introduced North American taxa have been uncertain for a long time, mainly because North American physids in general have been in taxonomic disarray right up to the present (Te 1978, 1980; Taylor 1988). An opportunity is taken here to clarify the current position with regard to *Physella acuta* and discuss its possible origins within the British Isles and Europe.

MATERIALS AND METHODS

Study material was derived from personal collections in Ireland and the Canary Islands of live and alcohol specimens, from alcohol voucher material sent by Mrs N. F. McMillan from the Liverpool area, and from alcohol vouchers sent from Ayrshire and Somerset as a result of an appeal published in the *Conchologist's Newsletter* (Anderson 2000). Dr R.T. Dillon of Charleston College, U.S.A. kindly donated material of *heterostropha* and *gyrina* from South Carolina and Virginia respectively.

[1] Department of Agricultural and Environmental Science, The Queen's University of Belfast and Department of Agriculture and Rural Development, N. Ireland, Newforge Lane, Belfast BT9 5PX.

Ireland Glastry (Irish Grid J638630), Co Down (coll. R. Anderson, 19/ii/2000).
England Hatchmere (SJ522722), Cheshire (coll. I. D. Wallace, 9/xi/1997); "Westwood" pond (SJ341826), Uplands Road, Bromborough, Wirral, Cheshire (coll. N. F. McMillan, 13 May 1998). Ewloe sandpit (SJ498868), Upton, Widnes, Lancs. (coll. S. J. McWilliam, 5/iv/1996); St. James Cemetery (SJ355894), Liverpool Cathedral, Liverpool (coll. C. Felton, 6/x/1998); Roman Springs, Bath, Somerset (coll. J. Llewellyn-Jones, 19/i/1997).
Scotland Loudun Inn (NS596374), Loudun Hill, Ayrshire (coll. F. B. Woodward, 20/viii/2000).
Wales Cardiff (ST184805), (Cardiff Pond Survey, 8/ii/2000); Tyn y Morfa, Talacre (SJ122839), Flints. (coll. I. D. Wallace, 18/xi/1997).
Tenerife, Canary Islands Jardin Botanico, Puerto de la Cruz (coll. R. Anderson, 22/vii/1998).

Approximately sixty alcohol vouchers of *Physella heterostropha heterostropha* (Say) (det. R. T. Dillon) were available for comparison with European *acuta*.
U.S.A. Charles Town Landing State Park (32°48.40′N, 79°59.42′W), Charleston, South Carolina (coll. R. T. Dillon, 3/i/2000).

Collections of *Physella gyrina* from Ireland, Wales and fifty alcohol vouchers received from Virginia were used to compare with *acuta*:
Ireland Sandy Bay, Lough Neagh (J114713), Co Antrim (coll. R. Anderson; 2/xi/1995).
Wales Gwent Levels (ST240795, ST278844), Gwent (27/v/1999, 28/vi/1999).
U.S.A. 1.5 km west of Waynesboro (38°3.15′N, 78°55.86′W), Augusta County, Virginia (coll. R. T. Dillon, 27/xii/1999).

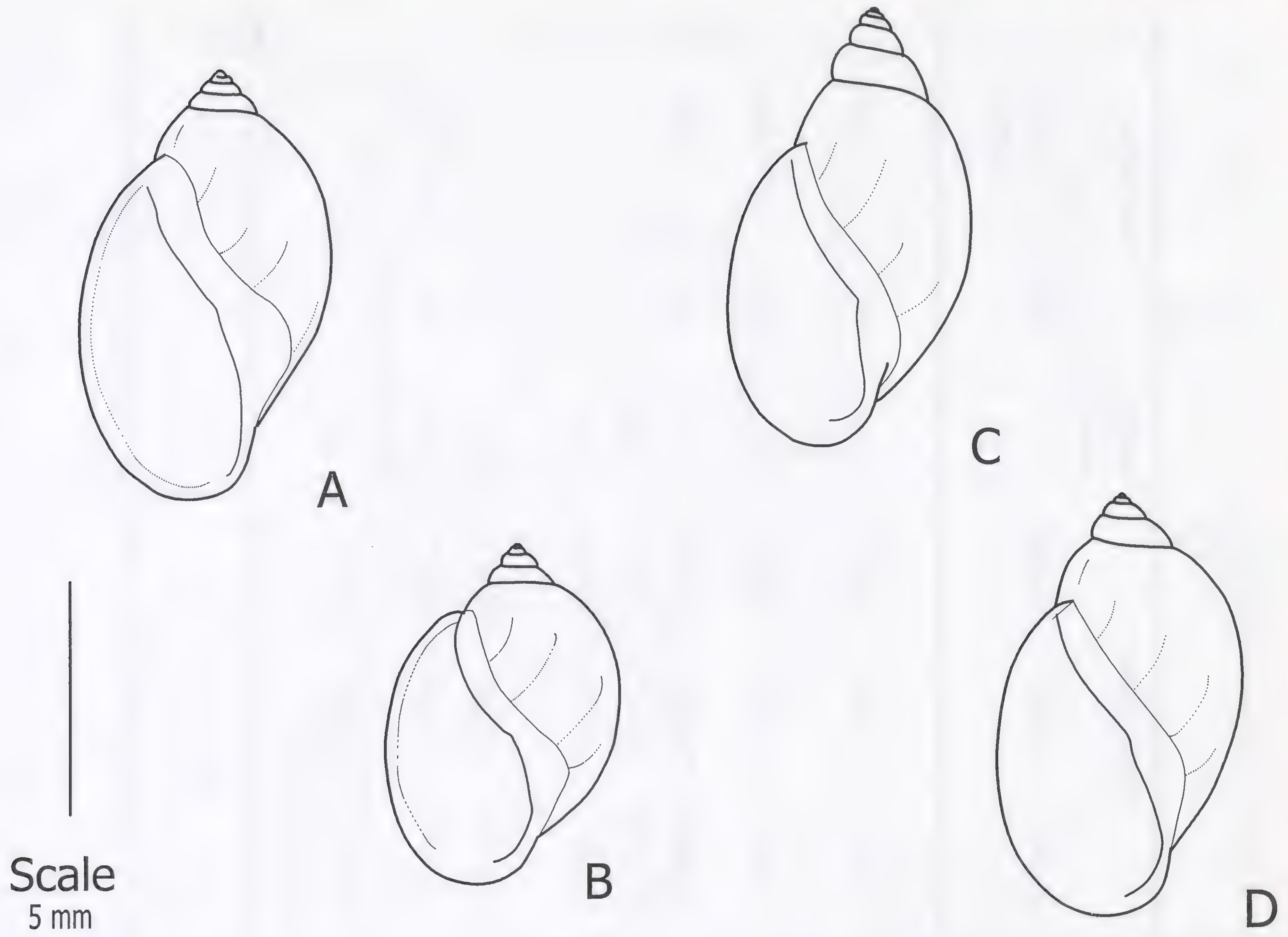
Alcohol specimens were removed from their shells which were retained and measured for shell height, shell width, aperture height and aperture width. These measurements were used to calculate ratios for shell height:shell width, shell height:aperture height and aperture height:aperture width.

The male genitalia of twelve specimens each of *acuta* from the Irish site at Glastry, of *acuta* from aquarium shops in N. Ireland, and of *heterostropha* from Charleston, U.S.A. were dissected out. These were spread out on HD polystyrene using stainless steel entomological micro pins and the proportions of the constituent parts measured by graticule on a Wild M3B stereomicroscope at x30 magn. The ratio of lengths of the praeputia and penial sheaths were calculated and drawings made of examples.

RESULTS

DESCRIPTION OF *PHYSELLA ACUTA*

Shell Sinistral, ovate, relatively solid to heavily calcified; spire acute, pointed but short; body whorl relatively broad and slightly shouldered; suture moderately incised; shell usually a dull horn-brown colour and in older shells with a black ferritic coating, although in many populations relatively glossy, pale-horn-coloured shells occur. Shells from base-rich habitats tend to be pale (whitish) and solid, with shell thicknesses more in keeping with marine than freshwater taxa (examples from Bath were of this type). Those from nutrient poor, acid or semi-saline habitats are often thin, poorly developed and horn coloured. In general, the aperture is ovate with the peristome meeting the body whorl at an acute angle though in intorted shells this may be closer to a right angle; parietal callus broad, white and slightly reflected over the columella; peristome simple, usually with a distinct white varicose thickening inside (absent or poorly developed in many shells, or differently coloured, sometimes pinkish or reddish). Shell height ranged from 5.5 – 9.08 mm at maturity in an Irish population selected for morphometric analysis (Table 1). The largest shell examined in this study was 10.88 mm (Hatchmere) but the



Figs 1a–d Shells of *Physella acuta/heterostropha* used in the study. **1a** typical, moderate-spired shell form of *P. acuta* from Glastry Clay Pits, Co. Down, Ireland. **1b** low-spired (intorted) shell form from Glastry. **1c** high-spired form of *acuta* from unheated tanks at a garden centre in south Belfast, Ireland. **1d** typical form of *Physella heterostropha* from Charles Town Landing Park, South Carolina, US.

species undoubtedly grows to 12 or 13mm.

A number of shells from the Glastry site in Ireland were squat and intorted (Figure 1b) so that the body whorl appeared relatively broad and with an exaggerated shoulder. A more typical shell is shown in Figure 1a. In other localities and in aquarium populations shells had more elevated spires (Figure 1c). These resemble the var. *gibbosa* Moquin-Tandon figured by Germain (1930) or the *Physella heterostropha* of Glöer & Meier-Brook (1998).

Mantle Digitate in two areas, with seven digitations on the right side furling round the columella and another four or five above the tail. As Ellis (1969) points out, the digitate mantle was for some unaccountable reason missed by Draparnaud (1805) in his description. Notwithstanding, there is a general consensus that *acuta* as described by Draparnaud is the common sharp-spired *Physa* or *Physella* of European authors.

Male genitalia In common with other spp. in *Physella* subg. *Costatella* the praeputium possesses an accessory gland and the penial sac is unitary and entirely muscular and glandular (Figure 2a; Pe). The praeputial gland is relatively small and adpressed in the distal (to male opening) end and the praeputium is large, thick-walled and melanin flecked. Internally the latter is pleated and vaguely sucker-like in the area corresponding to the praeputial gland with a long, pigmented pleat directed towards the male opening (Figure 3a). The penial sac is distal to this and slender and relatively unpigmented at least in British Isles material (Figure 2a; Pe). It usually appears distinctly shorter than the praeputium, but coiling makes direct comparison difficult. Germain (1930) described

TABLE 1

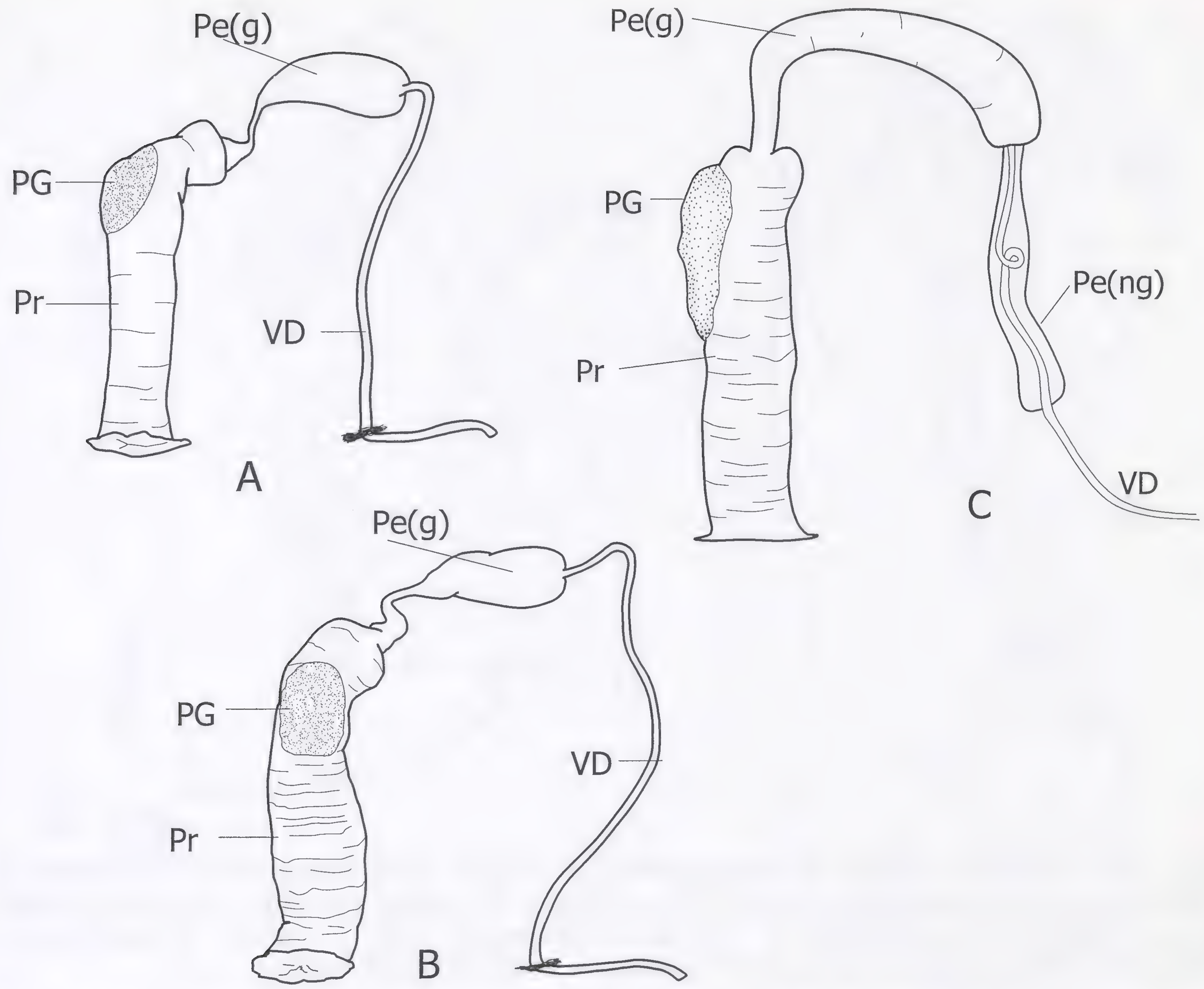
Summary of shell and genital morphometric analysis of Physidae

Origin	**Shell properties (means, mm)**					**Shell ratios**			**varix size**[3]	**Genitalia**	
	reps	height (H)	width (W)	apert. ht. (AH)	apert. width (AW)	**H:W**[1]	**H:AH**[1]	**AH:AW**[1]		reps	Ratio **Pr:Pe**[1,2]
A. *Physa heterostropha*											
South Carolina	28	8.67	5.49	6.58	3.15	1.58^{a}	1.314^{a}	2.118^{a}	0.4	12	1.489^{a}
B. *Physa acuta*											
Glastry	30	7.22	4.63	5.67	2.72	1.561^{a}	1.276^{a}	2.152^{a}	3.0	12	1.499^{a}
Aquaria	21	7.22	4.28	5.14	2.44	1.688^{c}	1.402^{b}	2.114^{a}	0.3	12	1.380^{a}
Bath	9	6.48	3.97	4.39	2.13	1.633^{ab}	1.474^{bc}	2.101^{a}	2.5	-	-
Tenerife	7	6.34	3.71	4.49	2.16	1.666^{b}	1.417^{bc}	2.084^{a}	0.4	-	-
C. *Physa gyrina*											
Virginia	21	8.53	5.26	6.37	2.86	1.620^{ab}	1.338^{a}	$2.226.^{a}$	5.8	-	-
Sandy Bay, L. Neagh	22	10.78	6.77	8.11	3.91	1.592^{ab}	1.329^{a}	2.082^{a}	0.8	-	-
Gwent levels	21	15.36	8.65	9.64	4.65	1.718^{c}	1.538^{c}	2.155^{a}	1.0	-	-

1 Means compared by single factor ANOVA with least significant difference (lsd) to discriminate individual differences: means with the same letter superscript in each column are not significantly different at $P<0.05$.

2 Pr:Pe = ratio of praeputium length to length of penial sac .

3 Development of varix assessed subjectively on a scale of 1 to 10 for individual shells. The means quoted give an overall estimate of the development of the varix in different populations.



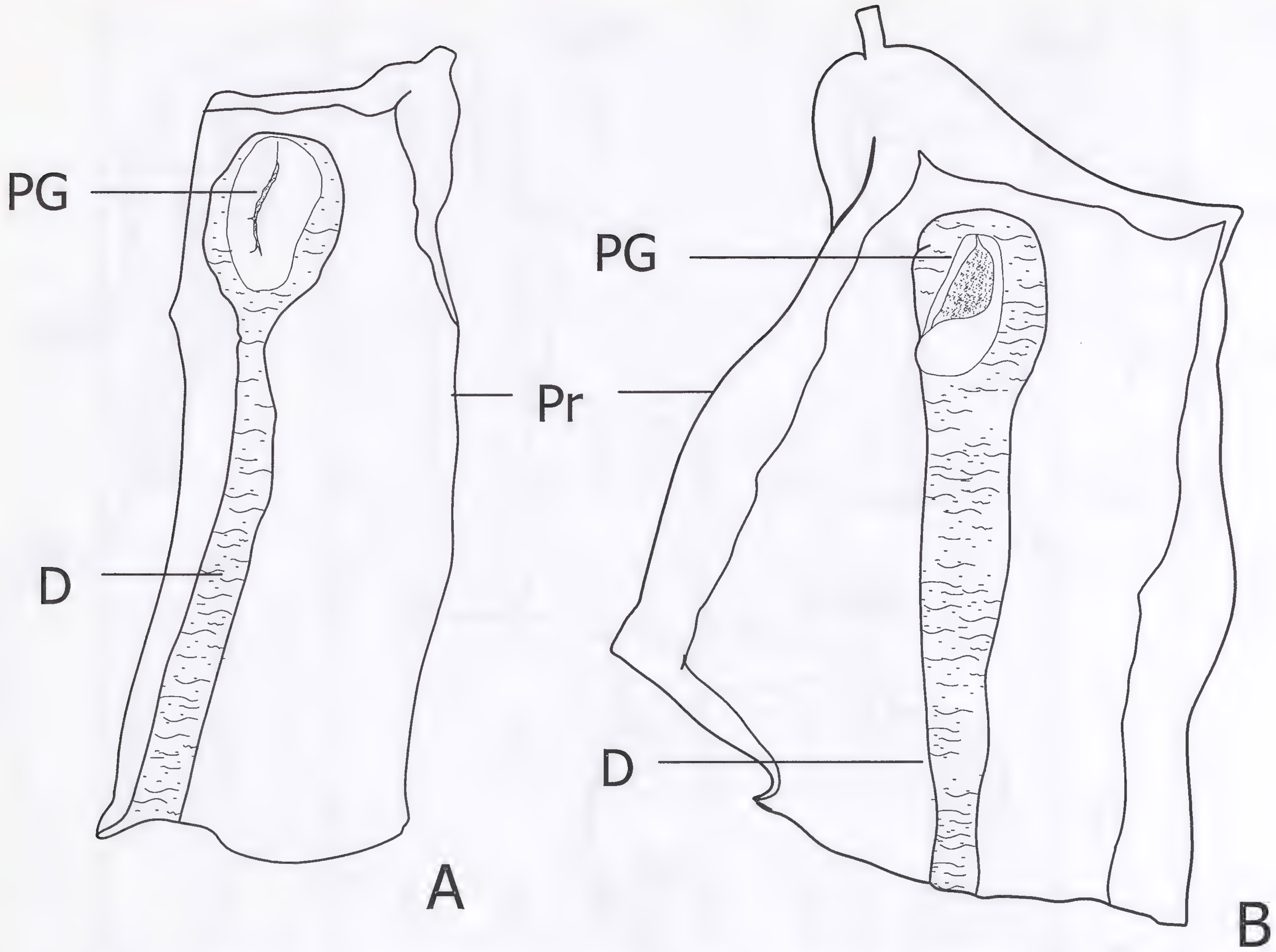
Figs 2a–c Proximal male genitalia from various Physidae. **2a** specimen of *Physella acuta* from Glastry Clay Pits, Co. Down, Ireland: **Pr** – praeputium; **PG** – praeputial gland; **Pe(g)** – penial sac, glandular; **VD** - vas deferens. **2b** specimen of *Physella heterostropha* from Charles Town Landing Park, South Carolina, US. **2c** specimen of *Physella gyrina* from Gwent Levels, Gwent, Wales: **Pe(ng)** – penial sac, non-glandular.

the penis as "*plus courte*" compared to the praeputium. There is a distal swelling in the penis but this appears to be less marked than in many other species of *Costatella* (cf. Te 1975). There is also a 'kink' where the proximal sac enters the praeputium which is characteristic of most or all species of *Costatella* (cf. Te 1975, Taylor 1988).

Body pigmentation Uniform pale gray to dark bluish gray with dark (black) pigment flecks scattered about the dorsum. Very few, small, white pigment granules have been apparent in some living examples.

COMPARISON WITH *PHYSA HETEROSTROPHA*

Shell Sinistral, ovate, relatively solid; spire acute, pointed but short; body whorl relatively broad and slightly shouldered; suture moderately incised. Shell form very similar to that of European *acuta* examined (Figure 1a) although the varix on the outer lip was absent or very reduced in the specimens from Virginia examined (Figure 1d). Spire relatively low and unlike the high-spired shells figured by Glöer & Meier-Brook (1998) and Turner *et al.* (1998) as this species. Colour is a uniform light horn with smooth and relatively glossy shell. Shell height ranged from 6.311–11.03mm in the twenty-eight specimens included in the morphometric analysis.

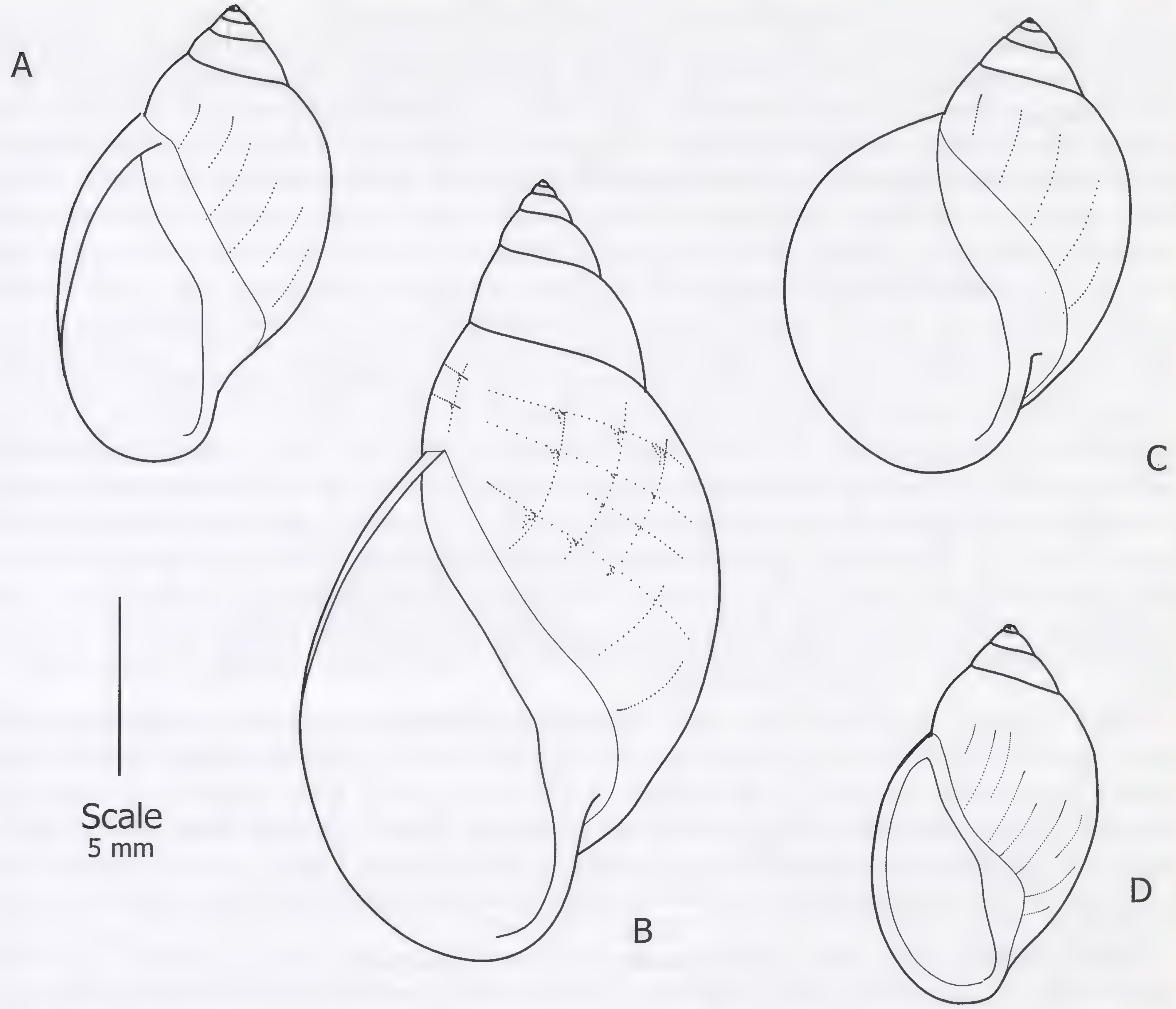


Figs 3a–b Internal structures of the praeputium in *Physella acuta/heterostropha.* **3a** specimen of *Physella acuta* from Glastry Clay Pits, Co. Down, Ireland: **Pr** - praeputium; **PG** – praeputial gland, internal sucker-like arrangement; **D** – ductus – long internal pleat to exterior. **3b** specimen of *Physella heterostropha* from Charles Town Landing Park, South Carolina, US.

Table 1 and Figure 4 show the results of morphometric comparisons. The South Carolina *heterostropha* clearly fall well within the wide range of variation of British Isles *Physa acuta* examined in this study. The frequency distribution of the ratios of shell height to width (Figure 5) for instance, show considerable overlap between *heterostropha* and *acuta,* and both have trimodal distributions (as do most other populations) indicating the presence of the discrete morphological variants earlier mentioned i.e. a slightly tumid form with moderately depressed spire which I would regard as *forma typica* (Figure 1a), a slender form with elevated spire (Figure 1c), and (more rarely) an intorted and much depressed form (Figure 1b). Several intorts were noted in the South Carolina *heterostropha* although these were much rarer than in the Glastry population of *acuta.* Overall there was considerable overlap between British Isles *acuta* and South Carolina *heterostropha.* Similar trends could be seen in comparisons of shell height: aperture height and in aperture height: aperture width. None of these comparisons attained significance in ANOVA comparing *heterostropha* with Glastry *acuta* (Figure 5; Table 1). Differences were, however, seen between Glastry *acuta* and *heterostropha* taken together, when compared with *acuta* from other sources such as aquaria.

Mantle Very similar to European *acuta.*

Male genitalia Structures and particularly proportions (Figure 2b) were indistinguishable from European *acuta.* Measured ratio of praeputium length to penis length in 12 dissected specimens of *heterostropha* was 1.489 whereas in 12 Glastry *acuta* the ratio was 1.499 (Table 1). Ratios ranged from 1.081 to 2.000 in *heterostropha* and from 1.067 to 1.857 in *acuta.* Differences were not statistically significant.



Figs 4a–d Shells of *Physella gyrina* from various localities. **4a** forma typica from Oxford Island, Co. Armagh, Ireland. **4b** very large, high-spired form from Gwent Levels, Gwent, Wales. **4c** form with expanded aperture from brackish water at The Cutts, Coleraine, Co. Londonderry, Ireland. **4d** small, heavily calcified form from Waynesboro, Virginia, US.

The degree of pigmentation in *heterostropha* was variable but usually intense in the proximal (to male opening) half of the praeputium, whereas in all of the *acuta* examined pigmentation was slight. This accords with general body colouration which was very dark in the South Carolina *heterostropha* compared to British Isles *acuta*. Germain (1930), however, records the praeputium in French *acuta* as *"trés pigmentée, presque noir"* so this is not an invariable feature of European *acuta*, and darkly pigmented variants have been noted by several authors. Lastly, the form of the praeputial gland was similar externally and internally to that of *acuta*, although internally the de-pigmented area corresponding to the external gland appeared slightly less elongate and more circular than in *acuta*, and the long internal pleat leading to the genital pore was generally more robust and thicker in diameter (Figure 3a,b). It is unlikely, however, that these features will prove to have taxonomic significance because of considerable within species variability.

Body pigmentation individual melanin flecks are scarcely distinguishable in alcohol material and the body is a uniform mid to dark bluish-gray.

COMPARISON WITH *PHYSELLA GYRINA*

Shell Sinistral, ovate, solid; spire acute, pointed but short; body whorl relatively broad but rounded; *suture shallowly incised*. Shell form less incised and angular than *acuta* (Figure 1a) *with much smoother contours running from whorl to whorl and almost flat sutures*. Shell texture varies from dull and matt to polished and shiny, with moderately incised striae through to completely smooth. The varix on the outer lip is also variable, from absent to strongly developed. Colour of the varix was a shade of brown in all material examined, varying from a rich reddish-brown to chocolate-brown or a purplish shade. The spire is relatively low in the Irish and Virginia populations but much higher in the Gwent and Cardiff populations. The aperture is also variable in shape but is usually more compressed laterally and less expanded than in *acuta*. A range of shell form is figured from moderate-sized with low spire (Figure 4a; Oxford Island, Ireland), to larger–sized with high spire (Figure 4b; Gwent Levels, Wales), or with excessively expanded aperture (Figure 4c; The Cutts, Coleraine, Ireland). Shell colour varies from light horn brown to deep red-brown. Height ranged from 6.3 to 10.35mm in the sample of shells from Virginia (Figure 4d) and from 8.7 to 12.75mm in an Oxford Island population (Table 1). Heights of up to 17.5mm have been recorded in Lough Neagh but the very large sizes are rare. In the Gwent Levels larger shells appear to be common with heights up to 22.1mm and in these shells a degree of malleation of the body whorl was noted (Figure 4b). Faint malleation has also been seen in some Lough Neagh populations.

Table 1 shows analysis of the shell dimensions. Differences from *acuta/heterostropha* are in general small, although average size of *gyrina* was in general greater. The Gwent Levels population of *gyrina* was unique in the particularly large shells with strongly elevated spires and large height:width proportions. These differed significantly from most other populations, except the aquarium populations of *Physella acuta* sampled ($P< 0.05$) which also had high spires. The plasticity of phenotype in these species is well illustrated.

Male genitalia *Physella gyrina* possesses type b genitalia (subgenus *Physella*). The penis is therefore in two parts. The first part, working inwards from the male opening, is a muscular, glandular sac (Figure 2c; Pe(g)) expanded distally and similar to the one-part penis in type c species. Distal to this is a non-glandular penis (Figure 2c; Pe(ng)) of similar or smaller length which may be narrow and parallel-sided throughout or else inflated and expanding apically (Figure 2c). The wall of the non-glandular penis is translucent and much less muscular than the glandular part. Inside is a narrow internal canal, often coiled as in Figure 2c. The internal canal joins directly to the vas deferens (Figure 2c). The praeputium is robust and melanin flecked with a large, non-adpressed, accessory gland. The isthmus joining the praeputium to penial apparatus is not so constricted as in type c species (e.g. *acuta*) nor does it have the kink characteristic of species in that group.

Body pigmentation In alcohol specimens colour is a uniform gray to bluish-gray. In living animals the dorsum is characteristically ornamented with clusters of large, white, pigment granules which give this species a distinctive appearance.

TAXONOMY OF *PHYSA ACUTA*

The taxonomy of the North American Physidae is complex and uncertain. Te (1978) made a substantial contribution to rationalising this but there are still a large number of nominal taxa of doubtful status.

An issue raised by Te's (1978, 1980) work relevant to the present report is the splitting of *Physa* into two main genera, *Physa* Draparnaud, 1801 and *Physella* Haldeman, 1843. Te based his decision to split *Physa* s.l. on F. C. Baker's work (1926) which put species with type-b and type-c genitalia in one genus (*Physella*) and those with type-a genitalia in another (*Physa* s.s). Te's genus *Physella* is further split into subgenera *Costatella* Dall, 1870 (for the species with type c genitalia e.g. the *acuta* group) and *Physella* (for species with type b genitalia, the *gyrina* group). Within *Costatella* there are also species with intermediate or type bc genitalia. Te (1980) placed these within a section, *Costatella,* of subgenus *Costatella,* with the *acuta* (type c) species group in section *Alampetista* Zilch, 1956. Te's position with regard to taxa found in Europe may be summarised as follows:

Physidae	**Taxa reported from Europe**
Subfamily Aplexinae	
Genus *Aplexa* Fleming, 1828	*hypnorum* (L.)
Genus *Stenophysa* Martens, 1898	
Subfamily Physinae	
Genus *Physa* Draparnaud, 1801	*fontinalis* (L.)
Genus *Physella* Haldeman, 1843	
Subgenus *Physella* Haldeman, 1843	*gyrina* (Say)
Subgenus *Costatella* Dall, 1870	
Section *Costatella* Dall, 1870	
Section (?) *Alampetista* Zilch, 1956	*acuta* Draparnaud [*heterostropha* (Say)]
Genus *Beringophysa* Starobogatov & Budnikova, 1976	
Genus *Petrophysa* Pilsbry, 1926	

There are several difficulties with this scheme. Taylor (1988) suggested that the split between species of type b and species of type c genitalia should, logically, be at the same taxonomic level as the split from those with type a genitalia i.e. in his scheme the three main subgenera of *Physa* should be *Physa* s.s., *Physella* Haldeman and *Haitia* Clench & Aguayo, 1932 (these can also be regarded as separate genera). The introduction of the name *Haitia* is unfortunate as this is clearly junior to *Costatella,* a name which Taylor (1988) appears to have overlooked. However, Taylor also pointed out that the type species of *Alampetista* Zilch, which is *Physa osculans* Haldeman, is a very obscure taxon without type material and interpreted very differently by different authors. He substituted *Haitia* for *Alampetista* but at a different taxonomic level from Te's (1980) classification.But it is unlikely that *Haitia* can replace *Alampetista* as the type of *Haitia, Physa elegans* Clench & Aguayo, is almost certainly in the species group with type bc genitalia and so cannot represent the *acuta* group of species (with type c genitalia), but rather the *cubensis* group where it is again junior to the name *Costatella.*

There is therefore ambiguity both about the taxonomic level for a split between the type b and type c groups, and about the name to be applied to the species group with type c (rather than bc) genitalia to which *Physella acuta* belongs. Nevertheless, it seems advisable to accept the classification of Te (1980) until a competent revision dealing with the outstanding issues becomes available.

STATUS OF *PHYSELLA ACUTA* WORLDWIDE

Physella acuta has been resident in British freshwaters since at least the late eighteen hundreds (Ellis 1969). It was described from France (Draparnaud 1805) and many European authors assumed that it was a native of Europe (Germain 1930).

However, doubts about its provenance began to surface towards the end of the twentieth century when it was clear that no other species within its subgeneric grouping occurred in the Palaearctic and its nearest relatives were therefore confined to the Nearctic (Te 1978, Brown 1980). The apparent absence of shell remains from European sediments older than the eighteenth century seems to confirm suspicions that *Physella acuta* is of North American, not European, provenance (Lozek 1964).

In North America there are an estimated 43 species of Physidae of which fifteen belong to the same subgenus as *Physella acuta* i.e. subgenus *Costatella* Dall, 1870 (Te 1980). Another species of *Costatella, Physella heterostropha* (Say), has been reported from European countries, including England (Ellis 1969, Macan 1977), Germany (Glöer & Meier-Brook 1998) Austria (Patzner & Szedarik 1996) and Switzerland (Turner *et al.* 1998). However, Anderson (1996) expressed doubts over the identity of the taxon involved. This is because workers in Europe have tended to base identification on shell morphology, a notoriously unreliable character for this group. The internal anatomy of European *'heterostropha'* is unpublished and no comparisons have been made with named North American material so it is impossible to know which species is intended. Published illustrations of shells have so far either been in error for *Physella gyrina* (Ellis 1969; Macan 1977) or could equally be one of the many shell morphs of *Physella acuta* (Glöer & Meier-Brook 1998, Turner *et al.* 1998).

Outside Europe *Physella acuta* has become pantropical in distribution and is recorded from every continent except Greenland and Antarctica (Te 1978, Brown 1980, Collier & Winterbourn 1986, Raut *et al.* 1995). It has been used widely in experimental ecology and behavioural studies because of the ease with which it can be bred in captivity. In the wild it exhibits a very short life cycle in suitable conditions, with very high growth rate and early maturity, and has a distinct competitive advantage in anthropically-enriched or temporary water-bodies (Perrin 1986; Appleton 1996). It has therefore proved highly invasive in many countries, competing successfully with indigenous molluscs, especially in man-altered habitats.

Its ability to tolerate a very wide range of climatic conditions, from cool temperate to tropical, is unusual and tends to suggest an origin in warm but not tropical latitudes, possibly the warm temperate or subtropical zones. There is also the strange ability to survive salinities which are lethal for most other freshwater species (Ashir *et al.* 1988), so it may have originated from coastal lagoons or waters subject to irregular saline incursion. Additional clues to its provenance have come from reports of disease-control work in east Africa. Hofkin *et al.* (1992) observed a remarkable predator-avoidance strategy in action when specimens of *P. acuta* were placed in tanks with the south-eastern US crayfish *Procambarus clarkii* (Girard). *Procambarus* was being tested as a control for molluscan vectors of schistosomiasis. It proved very effective for control of native African molluscs but when placed with *Physella acuta* its effect was minimal as the latter was observed to leave affected aquaria, thus avoiding predation. This can be interpreted either as a specific response to *Procambarus* or as part of a general 'retreat' strategy in the Physidae. *Physella virgata* Say, another of the North American species of the *acuta/heterostropha* group and native to Texas and adjacent states, exhibits a very similar response. Confined with *Procambarus simulans* (Faxon), a crayfish which is sympatric *with P. clarkii*, it also avoids predation by leaving the water (Alexander & Covich 1991). In this case the behaviour has been demonstrated to require a combination of damaged mollusc flesh *and* living crayfish in the aquarium i.e. the retreat response is not activated without a crayfish being present. Evidence of a specific response of this type between *Physella heterostropha* and *Procambarus clarkii* has now been published (McCarthy & Fisher 2000). The authors describe several strategies adopted by *"P. heterostropha pomila"* [sic] from Florida to avoid *Procambarus* including a burying response and an escape response. The close external and internal similarity between *acuta* and *heterostropha* should be noted here (Te 1978).

PHYSELLA ACUTA IN NORTH AMERICA

Te (1978) compared the male genitalia of a small sample of *acuta* obtained from Europe with American *P. heterostropha heterostropha*, one of its nearest relatives. Although the shells were not readily distinguishable small but consistent differences in the genitalia were claimed. Te was of the opinion that *P. acuta* would be very difficult to detect in North America because of its similarity to *P. heterostropha* and allied forms. He did not comment on its origins nor on its specific distinctness from *heterostropha*.

The circumstantial evidence for *acuta* originating from North America is nevertheless compelling. American authors have clearly been slow to appreciate this and little real progress has been made in identifying *acuta* under its assumed N. American identity. It is, however, possible to deduce a great deal from published accounts of the fauna. Te (1978) reviewed all of the taxa within the *Physella acuta/heterostropha* group recognised at that time. The best candidate in his account was *P. pomilia* Conrad (*P. heterostropha pomilia* auctt.), native to the south-eastern US, which appears to have all the attributes, including reported proportions within the male genitalia, noted for *acuta*. Thompson (1984) regarded *pomilia* as a southern subspecies of *P. heterostropha*. The range of *P. pomilia* is given as Missouri to Alabama (Wu *et al.* 1997) and Florida (Thompson 1984). However, it certainly occurs in the intervening states including the Mississippi state, Louisiana, the 'home' state of *Procambarus clarkii*.

Draparnaud discovered *acuta* in the River Garonne near Bordeaux and described it as a new species in 1805 (Draparnaud 1805). This supplies circumstantial evidence for an introduction since trade in cotton between the eighteenth-century French possessions on the Mississippi and ports in western France, including nearby Bordeaux, had been pursued for most of the latter half of the eighteenth century. The Napoleonic Wars ended this trade and France ceded Louisiana to the United States in 1803. Thereafter the cotton trade switched to British cities including Liverpool, and certainly resulted in the accidental import of the North American pulmonates *Menetus dilatatus* (Gould) and *Physella gyrina*, and of the sphaeriid bivalve *Musculium transversum* (Say) to Britain. *M. transversum* was first recorded near London in 1856, *M. dilatatus* near Manchester in 1869 and *P. gyrina* near Cardiff in 1918 (also subsequently in the cotton districts of Lancashire). The date at which *Physa acuta* first appeared in British habitats is uncertain but was probably in the latter half of the nineteenth century.

Claims that *Physella acuta* has been identified in North American habitats have been made recently. Wu *et al.* (1997) refer to its occurrence in Missouri under the trivial name 'lateritic physa' on account of a blackish incrustation of ferric oxide usually seen on the shell. The incrustation is used by these authors as a diagnostic character but is in all probability unreliable. In Europe encrusted shells are of frequent occurrence, particularly in older animals, but are by no means universal or exclusive to that species. Wu *et al.* (*op. cit.*) appear to have based their identification largely or entirely on conchological characters which is unwise given the history of this group. Both *Physella pomilia* and *P. 'acuta'* are illustrated by these authors but the figures pose even more questions about the reality of the supposed differences than they answer. As previously stated, the debate will not progress until the internal anatomy of these taxa is carefully examined and, preferably, breeding experiments conducted.

PHYSELLA ACUTA IN BRITAIN

A confirmed date for the first appearance of this species in outdoor habitats is elusive. It was unkown in native habitats in the middle of the nineteenth century (Jeffreys 1862; Forbes 1853), although Jeffreys refers to what may have been an early indoor record for Kew. A curious record which may relate to *Physella acuta* is given by Parke (1863). The author presumed that he had found a saline-tolerant dark form of *Physa fontinalis* in a recently salinated lagoon on the tidal Trent in Lincolnshire. *Physa fontinalis* has not otherwise been reported as a saline-tolerant species, but *Physella acuta* certainly is and was found in saline conditions at Tyn y Morfa, Talacre, Wales in the present study. Ashir *et al.* (1988) showed experimentally that *acuta* has moderate tolerance for raised salinity and could survive for extended periods in up to 4% sodium chloride.

By the early twentieth century Ellis (1926) was able to list records for Kew, Kettering, Oxford, Bath, Birmingham, St. Albans, Cambridge, Glasgow and Dublin. However, some of these sites (Kew, Glasgow and Dublin certainly) refer to artificially heated or greenhouse environments. Others records may be of *Physella gyrina* rather than *acuta/heterostropha* including that of Madison (1899) for a pool in the west of Birmingham. *Physella acuta* probably underwent a considerable expansion of range in semi-natural habitats between this time and the publication of Kerney's (1976) *Atlas* which shows a very wide range in England and Wales from Cornwall to London and north to Lancashire. It is likely that Kerney's records of "*Physa* cf. *acuta*" more or less correctly indicate the distribution of *acuta* s.s., as those which I have been able to examine are confirmed and *acuta* is undoubtedly the most widespread *Physella* in Britain. The *acuta* records cannot, however, be supplemented by Kerney's "*Physa* cf. *heterostropha*" even though *acuta* and *heterostropha* are probably synonymous, because of an unrelated error which appeared in texts of the time (Ellis 1969 – first edition 1926; Macan 1977 – first edition 1949). These texts conflated *acuta/heterostropha* with the anatomically distinct and larger *Physella gyrina*, and made it impossible to determine whether the '*heterostropha*' records relate to *acuta/heterostropha* or to *gyrina*. Ellis corrected his error in the 1969 reprint of his book but I suspect that many incorrect field determinations had already been canonised by repetition at this stage.

PHYSELLA ACUTA IN IRELAND

The earliest Irish sites are given by Stelfox (1911) as the Botanical Gardens, Glasnevin, Dublin, the lily tank in the Botanic Gardens, Belfast (coll. Phillips, 1909) and the lily tank at Castlewellan, Co. Down, all artificially heated. The records for Dublin and Belfast have recently been confirmed (R. Anderson, i/2000), but the Castlewellan colony is now gone. The presence of other alien *Physa* was suggested at the time but there was great uncertainty in diagnosis and the *acuta* from Glasnevin was compared on shell characters with *Physa gabbi* Tryon which is now known as *Physella virginea* (Lea), in subgenus *Physella* i.e. close to *gyrina* rather than *acuta*. Welch (1930) recorded an alien *Physa* in the Italian Garden, Mountstewart, Co. Down, and similarly suggested an affinity to *Physa gabbi*, or else (confusingly) "*P. forskegi*" (sic) (= *P. forsheyii* Lea?, now in synonymy with *Physella anatina* (Lea), a member of the *acuta* group in subgenus *Costatella*). There is nothing at Mountstewart now, so the species intended in this record will never be known.

A small survey of tropical fish outlets and garden centres in Northern Ireland during 1999 showed *acuta* (identified on morphology of the male genital tract) to be both widespread and common in tropical and coldwater aquarium tanks. Specimens collected in tropical tanks comprised a mixture of *forma typica* with a high-spired morph, while those from cold water tanks were invariably high-spired, similar to the var. *gibbosa* Moquin-Tandon figured by Germain (1930). Internally they were uniformly referable to *acuta*.

In addition there is a single confirmed outdoor record for Ireland:

Down: Glastry Clay Pits (J638630), coll. R. Anderson, 19/ii/2000. Common among macrophytes and on stones. Water-filled clay pits with a rich macrophyte vegetation including the aliens *Crassula helmsii* (Kirk)Cockayne and *Azolla filiculoides* Lam.

Associated Mollusca: *Lymnaea stagnalis* (L.); *Gyraulus albus* (Müller); *Potamopyrgus antipodarum* (Gray); *Sphaerium corneum* (L.).

Other fauna: *Crangonyx pseudogracilis* Bousf.[2] [Amphipoda]; *Asellus aquaticus* (L.) [Isopoda].

The species is well placed to invade freshwaters elsewhere in eastern Ireland. Its arrival in Ireland is a recent phenomenon as the Glastry ponds date only from the 1950s.

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[2] *C. pseudogracilis* is a recent introduction from N. America spreading rapidly in the British Isles (Dick *et al.* 1999)

A survey of disturbed aquatic environments near the east coast in the northern counties of Ireland has yielded no further localities to date. However, the possiblity of its occurrence further south cannot be excluded. The present record is symptomatic of an expansion of range which has been in progress for the last century and a half and looks set to continue in an era of global warming.

CONCLUSIONS

From the foregoing comparisons it is clear that the shell morphology of *Physella acuta* from the British Isles and Tenerife is extremely variable but that the internal anatomy is much more uniform and consistent with the concept of *Physella (Costatella) acuta* defined by European authors up to Germain (1930). A sample of the North American species *Physella heterostropha heterostropha* examined here falls well within the range of variation of British Isles *acuta* examined and the internal anatomy is indistinguishable so it is but a short step to reduce the latter to synonymy with *acuta* (the older name). Breeding experiments and DNA analysis are being performed on samples of *acuta* from Europe (including material from the Irish site at Glastry) with the North American taxa *P. heterostropha* and *P. integra* by a group led by Rob Dillon of Charleston College. Preliminary results (Wethington *et al.* 2000) suggest that there is insufficient evidence of genetic isolation between the three 'species' to consider them specifically distinct. It may be that very few of the North American species of *Physella* will be deemed worthy of specific rank under this type of scrutiny. Results presented in the present study suggest strongly that *Physella heterostropha* at least, should be reduced to synonymy with *Physella acuta.*

Within the British Isles the available confirmed records suggest that *Physella acuta* is the most widespread of the alien Physidae with a distribution probably well indicated by the map in Kerney's (1976) *Atlas* of non-marine Mollusca. The only other alien taxon is probably *Physella gyrina,* whose distribution is again best interpreted using the relevant map in Kerney (1976), at least until we know more. The two species, *acuta* and *gyrina,* can often be distinguished in the field on shell size, the form of the varix, or even on pigmentation in live animals (Anderson 1996; Table 1). However, these characters, while valid in the present study and probably more widely, should wherever possible be supplemented by examination of the male genitalia before a record is accepted.

The British Isles records of *Physella* listed here and those of Dean (1920) and Anderson (1996, 2002) for *Physella gyrina* (based upon dissection) are at present the only records which can be wholly relied upon.

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MULTIVARIATE ANALYSIS OF SHELL CHARACTERISTICS IN *AGATHYLLA EXARATA* (ROSSMÄSSLER 1835) (GASTROPODA: CLAUSILIIDAE) POPULATIONS AND ITS TAXONOMIC RELEVANCE.

ZOLTÁN FEHÉR[1]

Abstract Important conchological features (number of whorls, shell height and width, aperture height and width, number of ribs over the penultimate whorl and the cervix) of Agathylla exarata *(Rossmässler 1835) populations were examined using the material of the Hungarian Natural History Museum and the Hungarian Geological Institute. Our multivariate analysis of variance (MANOVA) and discriminant function analysis (DFA) studies revealed that, on the basis of these quantitative characteristics, the* A. exarata *forms* mostarensis *(Brancsik 1889) and* denegabilis *(Küster 1847) can only be regarded as size variations and, hence, synonyms of the nominate subspecies. By contrast,* neumensis *Nordsieck 1970, having more distant ribs, was found well separable from the other population groups and could be confirmed as a distinct subspecies.*

Key words Clausiliidae, taxonomy, Agathylla, *multivariate analysis, Balkans*

INTRODUCTION

To our present knowledge, the genus *Agathylla* H. & A. Adams 1855 is distributed along the eastern coast of the Adriatic Sea from southern Dalmatia to northern Albania, and also in certain inland areas of Herzegovina, Albania and Epirus up to 60 kilometres from the sea. Toward the south, *Agathylla* becomes more sporadic and rare, so its populations in central and southern Albania, as well as Epirus, were discovered only in the previous decade (Nordsieck 1996, Gittenberger 1998, Erőss, Fehér & Szekeres 1999). This is an obligate petrophilic genus, and on limestone rocks they can often be found in large quantities.

Agathylla exarata (Rossmässler 1835) inhabits the northernmost part of the genus's distribution area: the nominate subspecies was described from the delta of the Neretva river; *mostarensis* (Brancsik 1889) is believed to live in Herzegovina between Mostar and Počitelj, and *neumensis* Nordsieck 1970 was found near Badžula, south of the Neretva delta. A further form, *denegabilis* (Küster 1847) was mentioned from the Velež mountain over Mostar, and from Mljet island (Küster 1847, Brancsik 1889). More recently, *denegabilis* was regarded only a synonym of the nominate form (Zilch 1977), thus the latest comprehensive study on the genus (Nordsieck 1972) deals only with the first three forms (fig 1., table 1.).

During this study some conchological parameters were analysed in the *Agathylla exarata* material of the Hungarian Natural History Museum and the Hungarian Geological Institute. The aim of our work was to find variables of taxonomic value; ascertain which *A. exarata* forms can reasonably be distinguished as subspecies, and elaborate an objective method for their identification.

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[1] Hungarian Natural History Museum, Dept. of Zoology, H-1088 Budapest Baross u. 13. Hungary. feher@zoo.zoo.nhmus.hu

TABLE 1

The described *Agathylla exarata* forms and their mentioning in the literature.

"Names" and "Sampling sites or distribution areas" are taken from the referred publications using the original spelling. Currently used geographic names are given in square brackets.

Form	Literature data	Name	Sampling site or distribution area
exarata	Rossmässler 1835	*Clausilia exarata Z.*	Macarsca in Dalmatien
	Küster 1847	*Clausilia exarata Ziegler*	in Dalmatien bei Fort Opus (Narenta)
	Charpentier 1852	*Clausilia exarata Ziegl. Rssm.*	Ragusa; Narenta Dalm.
	Westerlund 1884, 1901	*Cl. exarata* (Z.) R..	Dalmatien, Herzegowina
	Zilch 1977	*Agathylla (Agathylla) exarata exarata* (Rossmässler 1835)	Narenta bei Fort Opus [=Opuzen]
	Nordsieck 1972	*Agathylla (A.) exarata exarata* (Rossmässler 1835)	Bagalovići bei Metković
denegabilis	Küster 1847	Var. A. minor, apice fusco. *Clausilia. denegabilis* Ziegler	bei Lago auf der Insel Meleda [=Mljet]
	Charpentier 1852	β. Minor, gracilior, apice fusco. Küst.	Ins. Meleda [=Mljet]
	Westerlund 1884, 1901	Forma 1.) minor	---
	Brancsik 1889	*Agathylla exarata Zgl. v. minor Chrp.*	in altissimis decliviis montis Veleš prope Mostar
	Jaeckel, Klemm & Meise 1957	*A. e. minor West.* 1884 *A. e. denegabilis (Küst.)* 1847	both from Mljet Island
	Zilch 1977	*Clausilia exarata* [var. A. *minor; Clausilia denegabilis*], Küster [synonim for the nominate subspecies]	Dalmatien: (bei Lago auf der) Insel Meleda [=Mljet]
mostarensis	Brancsik 1889	*Agathylla exatara Zgl. v. Mostarensis*	in antiquis muris urbis Mostar praecipue prope celebrem pontem
	Nordsieck 1972	*Agathylla (A.) exarata mostarensis* Brancsik 1889	Počitelj bei Čapljina
	Zilch 1977	*Agathylla (Agathylla) exarata mostarensis* Brancsik 1889	"in antiquis muris urbis Mostar praecipue prope celebrem pontem".
neumensis	Wagner 1918	*Agathylla narentana*	S-Dalmatien: Bačula [= Badžula] a.d. Straße Metkovi - Neum, Bagalovići bei Metković
	Nordsieck 1970	Agathylla (s. s.) exarata neumensis nom. nov. für *narentana* (A. J. Wagner 1918) [non A. Schmidt]	Badžula bei Neum
	Nordsieck 1972	*Agathylla (A.) exarata neumensis* Nordsieck 1970	Mislina bei Metković, Klek bei Neum
	Zilch 1977	*Agathylla (Agathylla) exarata neumensis* H. Nordsieck 1970	S-Dalmatien: Bačula (= Badžula bei Neum), a.d. Straße Metkovic - Neum.

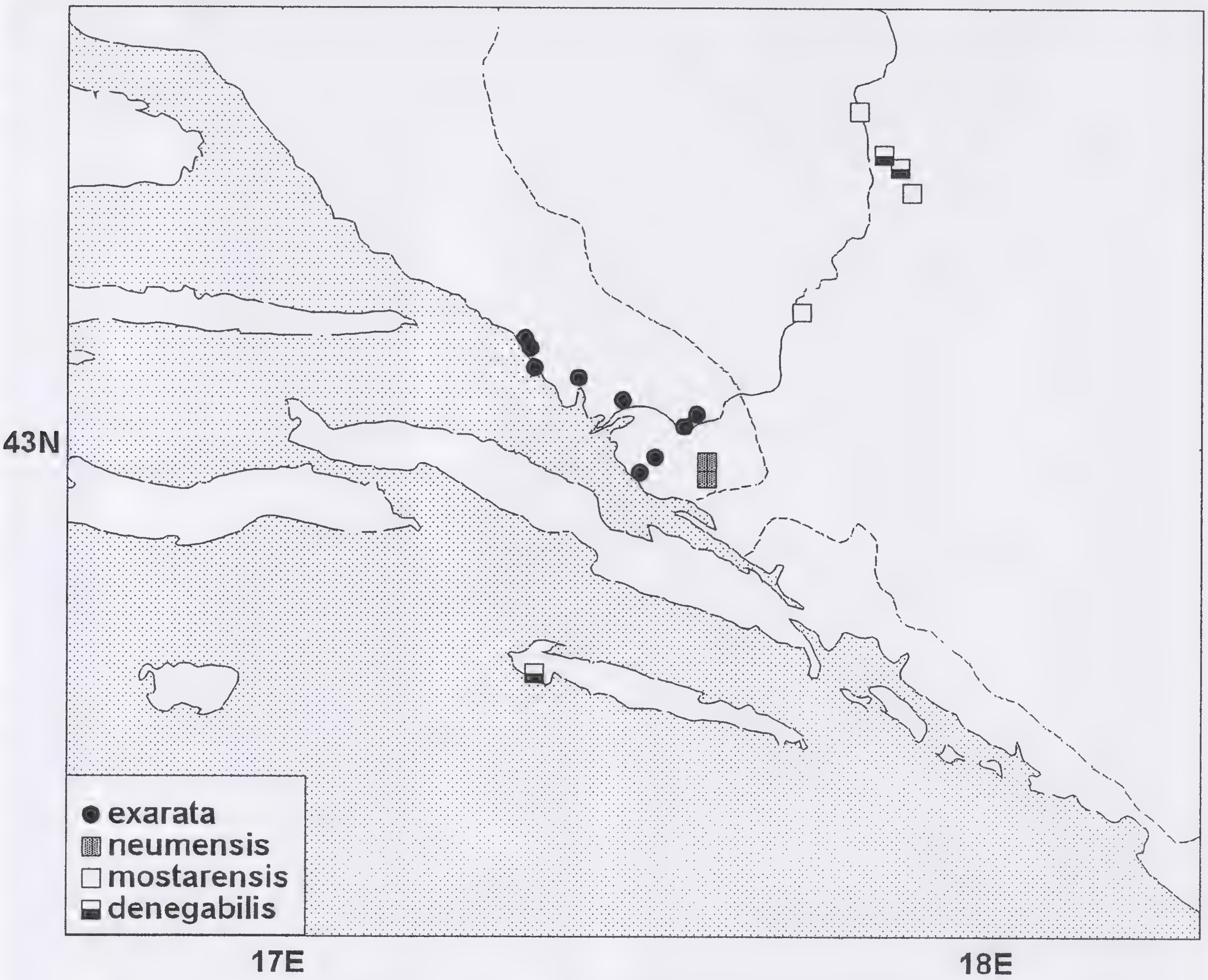

Fig.1 Geographic distribution of *Agathylla exarata* (Rossmässler 1835)

MATERIAL AND METHODS

Materials of the Hungarian Natural History Museum, Budapest (NHMB), and the Hungarian Geological Institute, Budapest (HGIB) were examined. Both collections contained material from the collections of T. Kormos and R. Streda, which had been donated by K. Brancsik. Those labelled as "*Clausilia exarata Zgl. var. mostarensis*" or "*Agathylla exarata mostarensis*" were considered as syntypes, and those designated as "*Clausilia exarata Zgl. f. minor*" were regarded the form to which the former one was compared in the original description (Brancsik 1889). The following samples were examined:

TABLE 2

Abbreviations for shell morphological parameters used in the text

H	shell height (mm)
W	spire width (mm)
H_A	height of the aperture
W_A	width of the aperture
N	number of whorls
RP	number of ribs on the penultimate whorl
RCS	number of ribs on the cervix
RD	rib density

Mostar area **Blagaj, Buna spring, near Mostar**: NHMB 10124/141 (13.11.1976. leg. Gy. Topál); NHMB 31077/5 (14.08.1966. leg. H. Nordsieck); NHMB 84820/2 (leg. A.J. Wagner / ex Museum für Naturkunde der Humboldt-Universität, Berlin ?); NHMB 84821/10 [10] (01.04.1999. leg. Erőss, Fehér, Kovács). **Gnojnice, near Mostar, over the village**: NHMB 43194/10 [8] (13.07.1985. leg. Kiss, Pintér). Podvelež, 3 km E of Donji Gnojnice: NHMB 84822/11 [10] (01.04.1999. leg. Erőss, Fehér, Kovács). **Počitelj, in the valley of the Neretva river**: NHMB 84824/4 (02.08.1981. leg. Z. Erőss); NHMB 84824/10 [10] (01.04.1999. leg. Erőss, Fehér, Kovács). **Mostar**: NHMB 09647/1 [1]; NHMB 31079/3 [3] (leg. K. Brancsik, SYNTYPUS "*mostarensis*"); NHMB 31635/5 [5]; NHMB 31674/9 [7] (ex R. Streda, ex K. Brancsik SYNTYPUS "*mostarensis*"); NHMB 64802/12 [12] (ex K. Brancsik SYNTYPUS "*mostarensis*"); NHMB 84825/4 [4] (ex R. Streda); HGIB-R4094 (ex T. Kormos, leg. K. Brancsik, SYNTYPUS "*mostarensis*"); HGI-R4095; HGI-R4096; NHMB 31675/3 [3] (ex K. Brancsik, "f. *minor*"); NHMB 84826/15 [15] (ex R. Streda, "f. *minor*").

Mljet island **"Dalmatia, Meleda" (=Mljet):** NHMB 10180/2 (leg. Tinter). **Mljet, Sv. Marija National Park:** NHMB 24382/8 (17.08.1976. leg. J. Podani); NHMB 42392/101 [11] (17.08.1976. leg. J. Podani, determined as *A. exarata exarata* by H. Nordsieck).

Neretva-delta **"Dalmatia":** NHMB 10181/1; HGIB-R4092 (ex T. Kormos, labelled as "*f. minor*"); HGIB-R4093. **"Narenta-valley"**: HGIB-R4091. **2 km E of Kremena:** NHMB 41179/165 [10] (12.07.1985. leg. Kiss, Pintér). **Rogotin**: NHMB 43195/134 [10] (12.07.1985. leg. Kiss, Pintér). **7 km SE of Gradač, over Bačinsko Jezero**: NHMB 84827/10 [10] (01.04.1999. leg. Erőss, Fehér, Kovács). **3 km NW of Ploče:** NHMB 84828/10 [10] (01.04.1999. leg. Erőss, Fehér, Kovács). **8 km NW of Klek (N of the conjunction to Raba):** NHMB 84829/10 [10] (02.04.1999. leg. Erőss, Fehér, Kovács). **Lovorje (near Neum):** NHMB 84830/8 [8] (03.04.1999. leg. Erőss, Fehér, Kovács). **2 km SE of Grada :** NHMB 84831/10 [10] (29.07.1998. leg. Z. Fehér). **"Gravosa" (=Gruž) (?):** HGIB-R4090 (1908. leg. Gagyi). **"Ragusa" (=Dubrovnik) (?):** HGI-R4089 (1905. leg. Weiss, ex T. Kormos).

Metković area **"Metković":** NHMB 85193/9 [9] (1936.09. leg. Knipper); HGI-R4088. **5,3 km N of Neum towards Badžula, at a monument**: NHMB 84832/2 (1982.09.01. leg. W. Fauer, type locality for "*neumensis*").

Conchological features of 177 specimens of 21 lots (underlined above) were involved in the statistical analyses. The numbers of examined specimens per lot are indicated in square brackets. 32 specimens of six different lots from Mostar were merged (Mostar I.), and those, labelled as "f.*minor*" (NHMB 31675/3, NHMB 84826/15) were also drawn together (Mostar II.), thus the examined specimens belonged to 15 groups (namely: Blagaj, Gnojnice, Podvelež, Počitelj, Mostar I., Mostar II. , Mljet, Kremena, Rogotin, Bačinsko Jezero, Ploče, Klek, Lovorje, Grada and Metković).

Several conchological features, including those, which were considered as important for this species (Rossmässler 1835, Brancsik 1889, Nordsieck 1972), were examined. Shell height (H), spire width (width of the widest whorl, W), aperture height (H_A) and aperture width (W_A) were measured by slide-callipers with 0,1 mm accuracy. As a consequence of the shell dimensions, the percentage of error is 5-7 times higher for the spire width and apertural sizes then for that of the shell height. The number of whorls (N) was measured with $^{1}/_{4}$ whorl accuracy. The number of ribs on the penultimate whorl (RP) and the cervix (RCS) was measured by the method of Welter-Schultes (2000). The rib density on the penultimate whorl (RD) was calculated as $RP/W{*}\pi$ (table 2.). Other shell characters that are difficult to measure, like the colouration and the structure of the clausilial apparatus, were examined and compared conventionally.

Mean, median, maximum, minimum, 10% and 90% percentile values were calculated

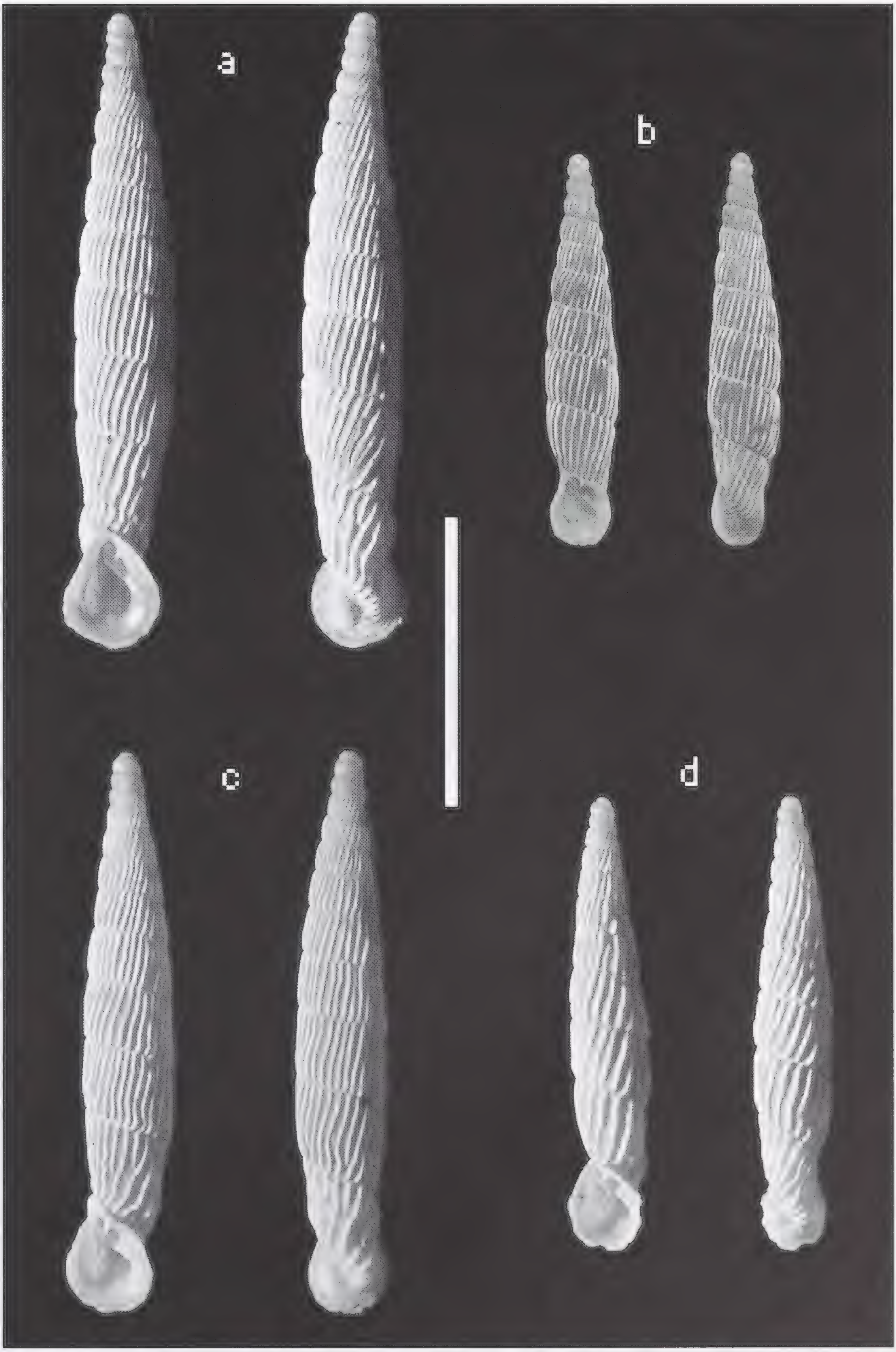

Fig. 2 Shell variations in the examined populations of *Agathylla exarata* (Rossmässler 1835) **a** Neretva delta region, which is the area typica of the nominate subspecies (Ploče, NHMB 84828) **b** Velež mountain (Podvelež, 3 km E of Donji Gnojnice, NHMB 84822) **c** a syntype specimen of *mostarensis* (Mostar, NHMB 64802) **d** a specimen from the type locality of *neumensis*. (5,3 km N of Neum towards Badžula, NHMB 84832). Scale bar = 10mm.

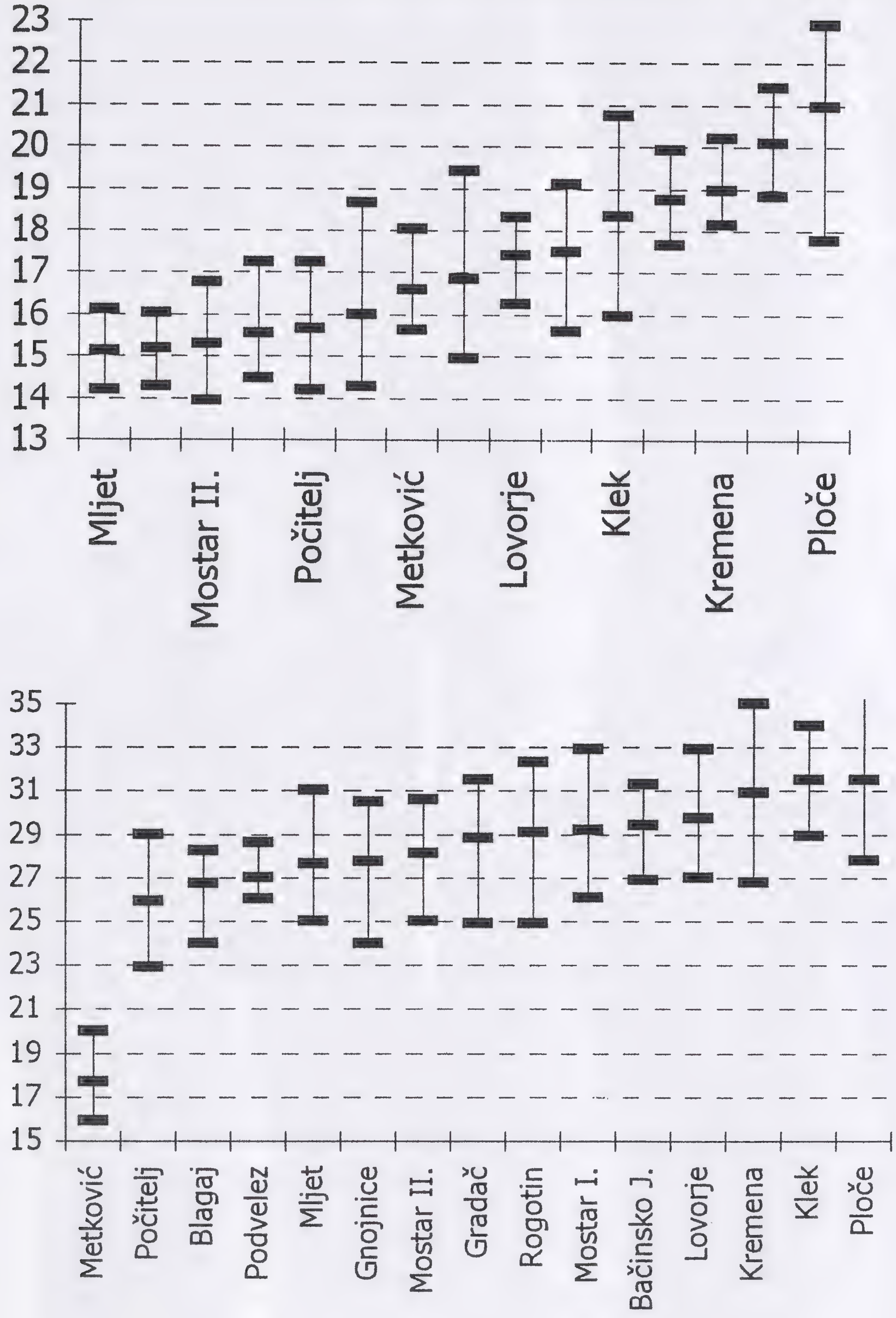

Fig. 3 Variation of shell characters in various *Agathylla exarata* populations. Median, 10% and 90% percentile values are plotted to ignore extreme values. **a** shell height (mm) **b** number of ribs over the penultimate whorl.

for each population and the homogeneity of variances was checked. The correlations between the variables were calculated. The populations were ordered by the mean values of each variable, and each "neighbours" were compared by t-test analysis (Hajtman 1971).

Discriminant function analysis (DFA) combined with multivariate analysis of variance (MANOVA) were performed in order to determine (i) which variables (shell characters) contribute to the discrimination between described subspecies and (ii) which subspecies a certain specimen or a population belongs to (Podani 2000).

Three preconceptual groups were designated, representing the subspecies, which were dealt with by Nordsieck (1972). The *exarata*-group consisted of ten randomly selected specimens from the populations of the Neretva-delta region (Gradač, Bačinsko Jezero,

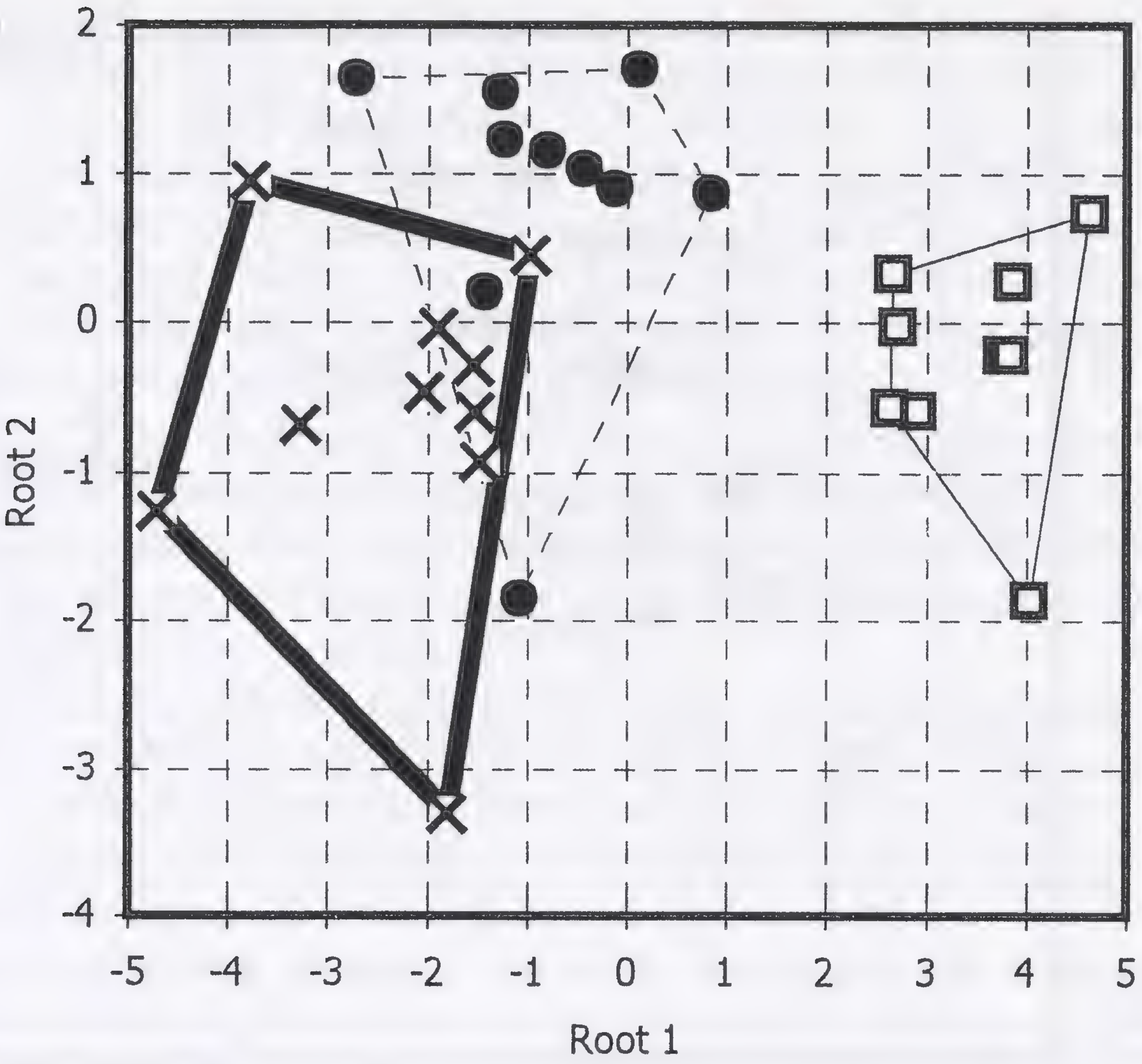

Fig. 4 Three described subspecies of the *Agathylla exarata* separated by discriminant function analysis (DFA). 29 specimens of three subspecies were selected - *exarata* (x), *neumensis* (empty squares) *mostarensis* (filled circles) - and their canonical scores were plotted for the two discriminant functions (roots). The 1st root, which pactically represents the ribbing of the shells, discriminates between *neumensis* and the others, and the 2nd root, which represents shell dimensions, discriminates between *exaratata* and *mostarensis* groups. The overlap of the points of the latter ones and the weak significance of the 2nd root makes their discrimination questionable.

Ploče, Klek, Lovorje), which is the area typica of the nominate form. The *neumensis*-group consisted of nine specimens from Metković, and the *mostarensis*-group consisted of ten randomly selected syntype specimens from Mostar. During these analyses four shell characters were used (H, W, N and RP) as original variables. During the DFA the original variables are replaced by "artificial" variables, called discriminant functions or roots, which are independent from each other, and the number of variables are reduced. In this case this was 2 (the number of the groups minus one). The first discriminant function provided the most overall discrimination between groups, more than any original variable alone. Canonical scores of the specimens in the preconceptual groups (i.e. their position in the space defined by the two discriminant functions) were calculated and plotted (fig. 4).

The overall discrimination of the three subspecies-groups was described by Wilks' λ statistics, which was computed as the ratio of the determinant of the within-groups variance/covariance matrix over the determinant of the total variance/covariance matrix. (Its value generally ranges from 0, meaning perfect discrimination, to 1, meaning no discrimination). The pair-wise discriminations of the groups were characterised by squared Mahalanobis distances (D^2), which are the squares of the distances between the group centroids. (A group centroid is the average of the canonical scores of specimens belonging to the same group.) The significance of the roots' contribution to the discrimination between the groups was tested by sequential Chi^2 test. Structure coefficients - correlations between the original variables and the discriminant functions - were then computed to see how the original variables contribute to the discrimination of the subspecies. Finally, the same discriminant function coefficients were used to compute the canonical scores for the rest of the 177 specimens and the group centroids

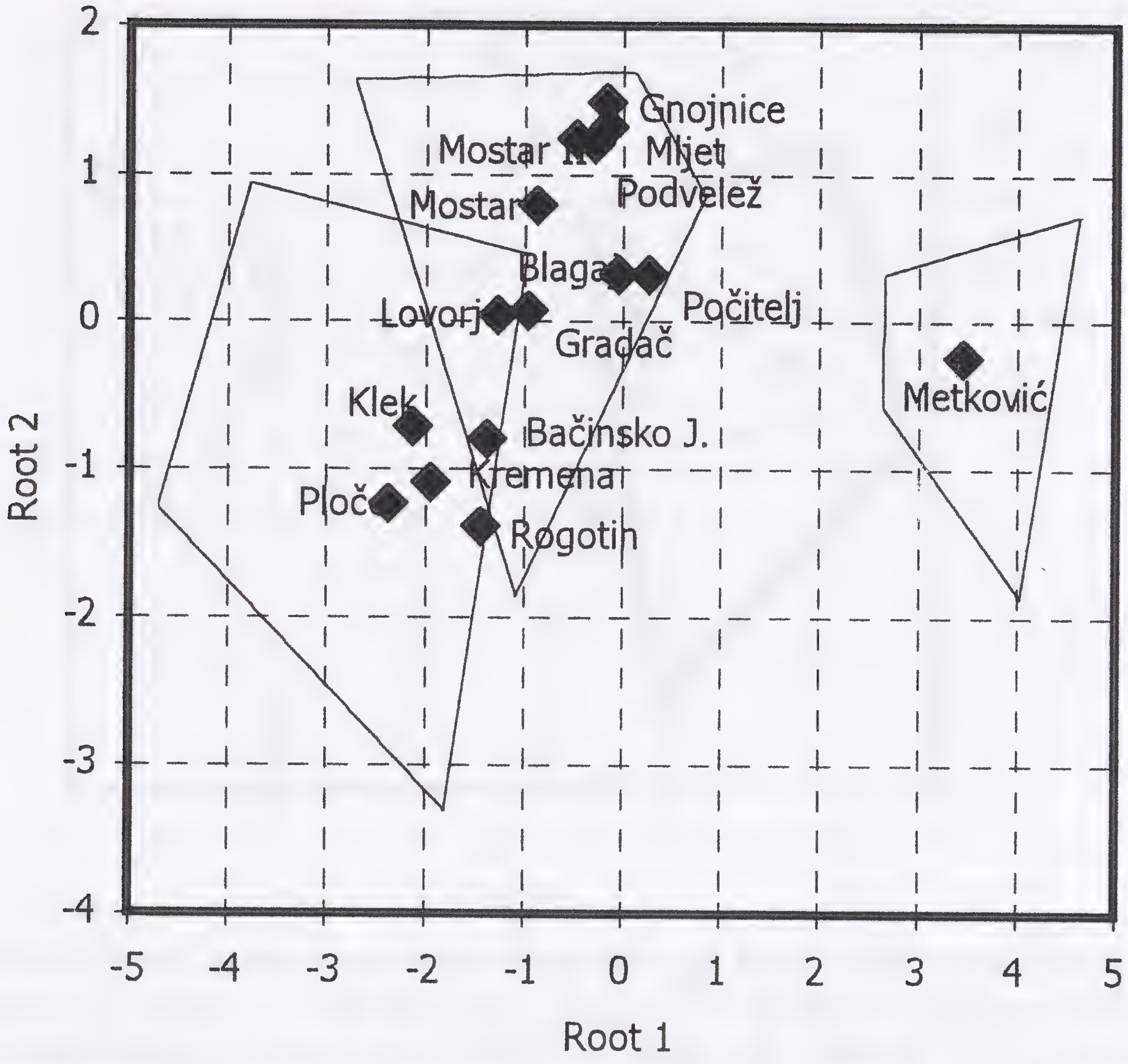

Fig. 5 Group centroids of the examined populations. First a discriminant function analysis was performed on three preconceptual groups, then the resulting canonical scores were applied to each specimen. These values were averaged within each population group, resulting group centroids. Except that of the *neumensis*-group, other centroids scattered more or less homogeneously along the 2nd root.

of every population, too. These scores were plotted in order to predict which subspecies a particular population belongs to (fig. 5).

RESULTS

Among the measured specimens shell height ranges between 13.2 mm (Počitelj) and 23 mm (Ploče), while spire width between 2.4 mm (Podvelež) and 3.7 mm (Klek). The number of whorls varies between $10^{1}/_{4}$ (Počitelj, Mostar) and $14^{1}/_{4}$ (Klek, Ploče). When comparing the populations by these variables, it is worth to note, that specimens in the Neretva delta are generally larger, while in the Velež mountain (Podvelež, Gnojnice, Mostar II.) and Mljet they are generally smaller than the average (fig. 2.). A considerable overlap could be seen between the populations ordered by the mean values of these variables (fig 3.). Comparing the neighbours of these series by t-test gave no significant differences. These results, however, should be interpreted carefully, since the groups are not independent (Hajtman 1971). H_A and W_A values varied from 2.5 to 4.1 mm and from 2.0 to 3.2 mm, respectively. Significant correlations ($p < 0.001$) were generally found between shell dimensions (H, W, H_A, W_A), the strongest ones being between H–N (0.87), H_A–W_A (0.84) and H–W (0.76).

Rib density was the highest in the specimens from the Velež mountain and Mljet island, the number of ribs, due to the larger circumference, is the highest in those of the Neretva delta region. Both the number of ribs and the rib density are the lowest in the Metković population. Excepting this latter population, the others are homogenous statistically, while Metković population differ significantly from all of them (RCS: 6–8; RP: 15–20; RD 1.6–2.4 vs. RCS: 8–14; RP: 22–37; RD: 2.3–4.3; $p < 0.0000001$) (Fig. 2.). However ribs were not counted in the upper whorls, but the Metković population is ribbed apparently sparser in the whole shell. Furthermore, ribs of the Metković specimens seem to be somewhat sharper and higher than those of the others. Regarding the RP and RCS values, the rest of the populations seem to be homogenous, without significant differences between the neighbours of the series (fig 3.).

Neither the colour of the shell nor the structure of the clausilial apparatus seemed to differentiate between the groups, therefore these characters were not dealt with further on. Considering that aperture dimensions showed correlation with the shell dimensions ($r \approx 0.6$), and the higher percentage of error of their measurements, H_A and W_A were excluded from the further analyses too.

It was shown by the MANOVA that at least one of the three preconceptual groups differs significantly from the others (Wilks' $\lambda = 0.094$, $F(8,46) = 13.0$, $p < 0.0000001$). The most important variable differentiating them is RP ($F(2,26) = 79.2$, $p < 0.0000001$), but effects of other variables are also significant (p-levels for W, H and N are 0.001, 0.007 and 0.038 respectively).

Pair-wise analysis of group distances resulted in significant squared Mahalanobis distances (D^2) between each pair (*mostarensis - exarata*: $D^2 = 4.8$, $p = 0.0058$, *mostarensis - neumensis*: $D^2 = 21.6$, $p < 0.0000001$, *exarata - neumensis*: $D^2 = 37.0$, $p < 0.0000001$). The 1st discriminant function (Root 1) separates *neumensis* group from the others, while the 2nd function separates the *exarata* and *mostarensis* groups from each other (fig. 4). Sequential Chi^2 test revealed that the 1st discriminant function contributes to the discrimination of the groups in a large extent ($x^2 = 57.9$, $df = 8$, $p < 0.0000001$). The contribution of the 2nd discriminant function however is less significant ($x^2 = 8.9$, $df = 3$, $p = 0.031$). Structure coefficients - the correlations between the original variables and the discriminant functions - showed that RP determines the 1st function almost exclusively ($r = -0.97$), and the 2nd function is determined mainly by W and H ($r = -0.61$ for both). If we would like to assign substantive "meaningful" labels to the discriminant functions, the 1st function can be labelled as "ribbing" and the 2nd one as "shell dimensions".

Individual canonical scores of each specimen and centroids of each population were calculated, then plotted in order to predict which subspecies a particular population belongs to. Except for Metković, the populations did not separate clearly; their sets of points overlap to a large extent; populations of the Velež mountain and Mljet (*denegabilis* form) grouped on the opposite side, compared to some populations of the Neretva delta (typical *exarata* form), while other populations of the Neretva delta and the Mostar area have intermediate positions (fig. 5).

DISCUSSION

In the latest review of the genus three distinct subspecies of *A. exarata* were distinguished, and the number of ribs over the penultimate whorl was assigned as the main distinguishing feature. The mean values of rib number per 2 mm were given as 8.0 for *exarata*, 7.8 for *mostarensis* and 5.7 for *neumensis* (Nordsieck 1972). Apart from the methodical problems of Nordsieck's rib-count (Welter-Schultes 2000), neither the range, nor the variance values were given in this study, so it is impossible to assess if the given mean values differ significantly.

This study shows that the Metković population (*neumensis*) can be distinguished from the others both by the number and/or density of the ribs. From a practical point of view, the number of ribs over the penultimate whorl seems to be the best distinguishing mark, which ranges between 15 and 20 for *neumensis* and 22–37 for the other groups. In this case only one variable can satisfactorily distinguish a subspecies, thus the application of a multivariate method is unnecessary.

By contrast, due to the overlapping characters, difficulties were experienced during the classification of the other populations and designation of the boundaries of *mostarensis*. Unfortunately, Brancsik's original description (1889) does not help to distinguish *mostarensis* from the nominate form. It compares *mostarensis* to *"Agathylla exarata Zgl. v. minor Chrp."* living in the high regions of the Velež mountain, and from which *mostarensis* differs by its larger shell and aperture dimensions, and sharper and denser ribs. The form *minor*, described not by Charpentier (1852) but Küster (1847), is a synonym of *Clausilia denegabilis* (Küster 1847) from Mljet (table 1.). The large distance between the Velež mountain and Mljet makes highly questionable any closer relationship between these populations, but the result of the DFA in the present study confirmed Brancsik's opinion, namely that these populations are morphologically very similar. Regarding the rib density, *mostarensis* is believed to be somewhere between *denegabilis* and *exarata*, since *mostarensis* is ribbed denser and sharper than *denegabilis* (Brancsik 1889), and *exarata* is ribbed denser than *mostarensis* (Nordsieck 1972). According to the shell dimensions given by various authors (Rossmässler 1835, Küster 1847, Westerlund 1884 and 1901, Brancsik 1889) *mostarensis* also stands between *denegabilis* and *exarata*. This intermediate position of *mostarensis* could be confirmed by the present study (fig 5.), indicating that *mostarensis* could only be considered a distinct subspecies if *denegabilis* was that too.

However the considerable overlap of quantitative conchological features made a clear separation of these groups impossible even by using multivariate methods. Consequently, our present conchological analyses strongly suggest that the whole *exarata - mostarensis - denegabilis* group should be considered as a continuous range of geographical variations, therefore *mostarensis* and *denegabilis* forms have no subspecific value, they are synonyms of the nominate subspecies.

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The author is grateful to E. Krolopp for the possibility of examining the material in the Hungarian Geological Institute. Thanks are due to J. Pelbárt for making the photographs and to M. Szekeres and J. Podani for their useful comments. The distribution map was drawn using DMAP 7.0 (www.dmap.ac.uk).

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PRELIMINARY REVISION OF THE *MONACHA* (*PARATHEBA*) *ROTHII* (L. PFEIFFER, 1841) SPECIES COMPLEX FROM THE AEGEAN REGION (GASTROPODA: HYGROMIIDAE)

B. HAUSDORF[1]

Abstract A preliminary revision of the Monacha (Paratheba) rothii *(L. Pfeiffer, 1841) complex revealed conspicuous differences in the proportions of the genitalia and shell sculpture. The complex includes at least four species.* Monacha (Paratheba) rothii *(L. Pfeiffer, 1841) is restricted to the Cyclades, Monacha (Paratheba) pseudorothii n. sp. to the East Aegean islands from Ikariá to Anáfi,* Monacha (Paratheba) maasseni *n. sp. to southern Rhodes and* Monacha (Paratheba) cretica *n. sp. to western Crete. The distribution of these species and anatomically unknown forms of the complex is illustrated on an UTM-grid-map.*

Key words Monacha, Paratheba, *Hygromiidae, systematics, distribution, Greece.*

INTRODUCTION

Monacha (*Paratheba*) *rothii* (L. Pfeiffer, 1841) from the Aegean region is thought to be well differentiated by its conchological characters: the closely coiled, whitish shell with a distinctly limited brown band above the periphery and a minute, almost completely or completely covered umbilicus can easily be distinguished from all other *Monacha* species.

M. rothii is also biogeographically exceptional. Whereas all other *Paratheba* species are restricted to the Pontian region, *M. rothii* is distributed in the Aegean. It is questionable, however, whether *M. rothii* is actually closely related to the *Paratheba* from the Pontian region, because no autapomorphies of *Paratheba* are known (Hausdorf, 2000a, b).

The genitalia of *M. rothii* have been described by Hesse (1931), Fuchs & Käufel (1936), Maassen (1981) and Reischütz (1986). Fuchs & Käufel (1936) have found conspicuous anatomical differences between populations. In the course of a revision of the *Monacha* species of Turkey (Hausdorf, 2000a), it has been found that there are also conchological differences between populations classified with *M. rothii* and that the anatomical differences described by Fuchs & Käufel (1936) far exceed the intraspecific variation known from other *Monacha* species.

A revision of the *M. rothii* complex is therefore necessary. This preliminary revision is limited by the availability of adult alcohol-preserved specimens. However, examination of the available preserved material of the *M. rothii* complex proved that there are at least four distinct species. Considering the number of isolated islands (or island-groups) from which forms of the complex are known, the true number of species might be twice as high or even higher.

MATERIAL AND METHODS

The counting of the shell whorls (to the nearest 0.25) follows Kerney & Cameron (1979: 13). The terms proximal and distal refer to the position in relation to the gonad.

The material on which this study is based is kept in the following collections:

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[1] Zoologisches Institut und Zoologisches Museum der Universität Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany.

BAN	Collection R. A. Bank.
GIU	Collection F. Giusti.
LIE	Collection A. Liebegott.
MAA	Collection W. J. M. Maassen.
NHMW	Naturhistorisches Museum, Wien.
NHMWE	Collection Ä. Edlauer in the NHMW.
NHMWF	Collection A. Fuchs, anatomical preparations in the NHMW.
NHMWK	Collection W. Klemm in the NHMW.
NNM	Nationaal Natuurhistorisch Museum, Leiden.
REI	Collection P. L. Reischütz.
SMF	Senckenberg-Museum, Frankfurt a. M.
ZMH	Zoologisches Institut und Zoologisches Museum der Universität Hamburg.
ZMZ	Zoologisches Museum der Universität Zürich.
ZSM	Zoologische Staatssammlung, München.

The material lists include only specimens which have been examined anatomically or which can unambiguously be assigned to the anatomically delimited species.

Additional abbreviations: D = shell diameter; det. anat. = anatomically determined; H = shell height; leg. = collected by.

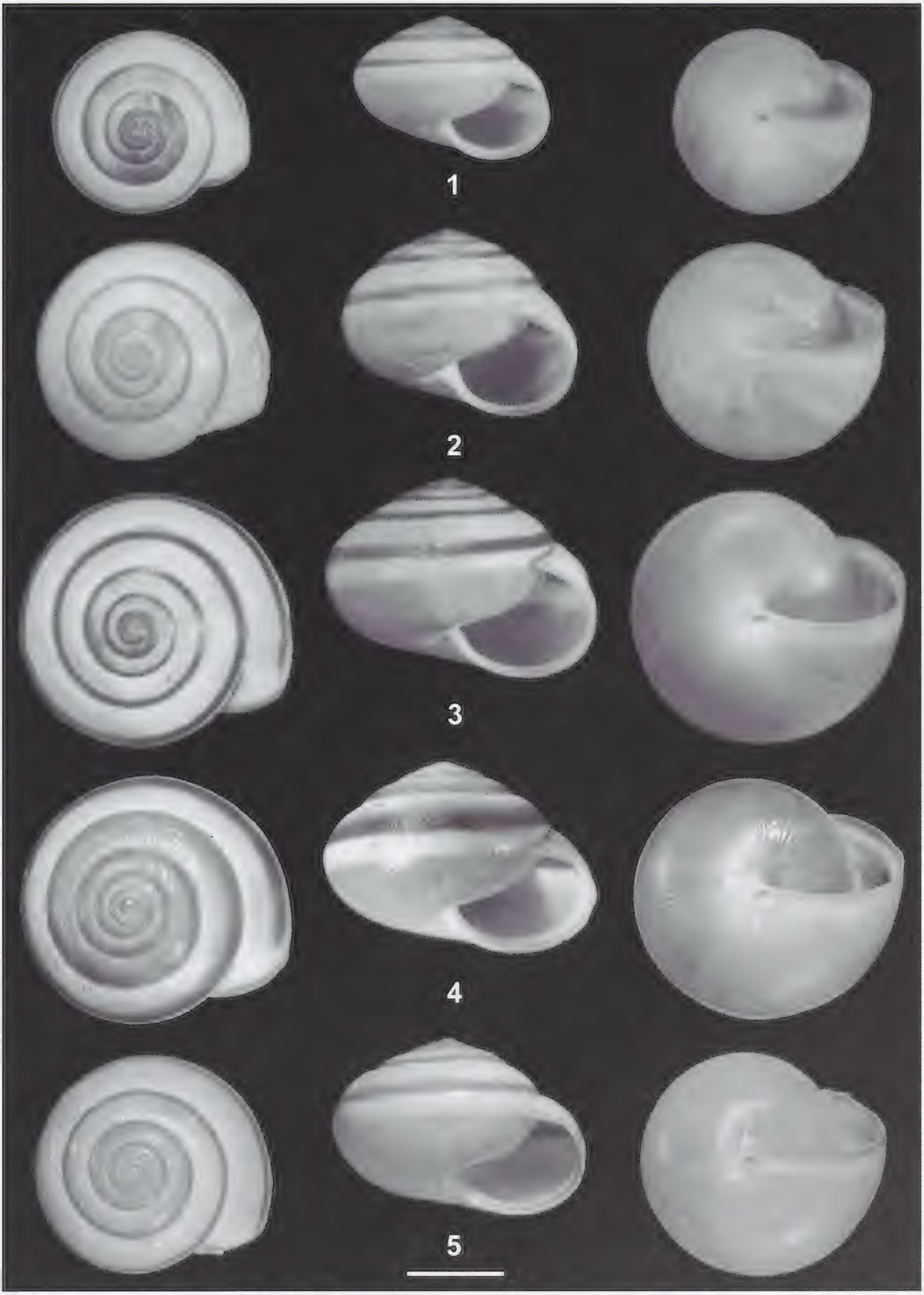
SYSTEMATICS

Monacha (*Paratheba*) *rothii* complex

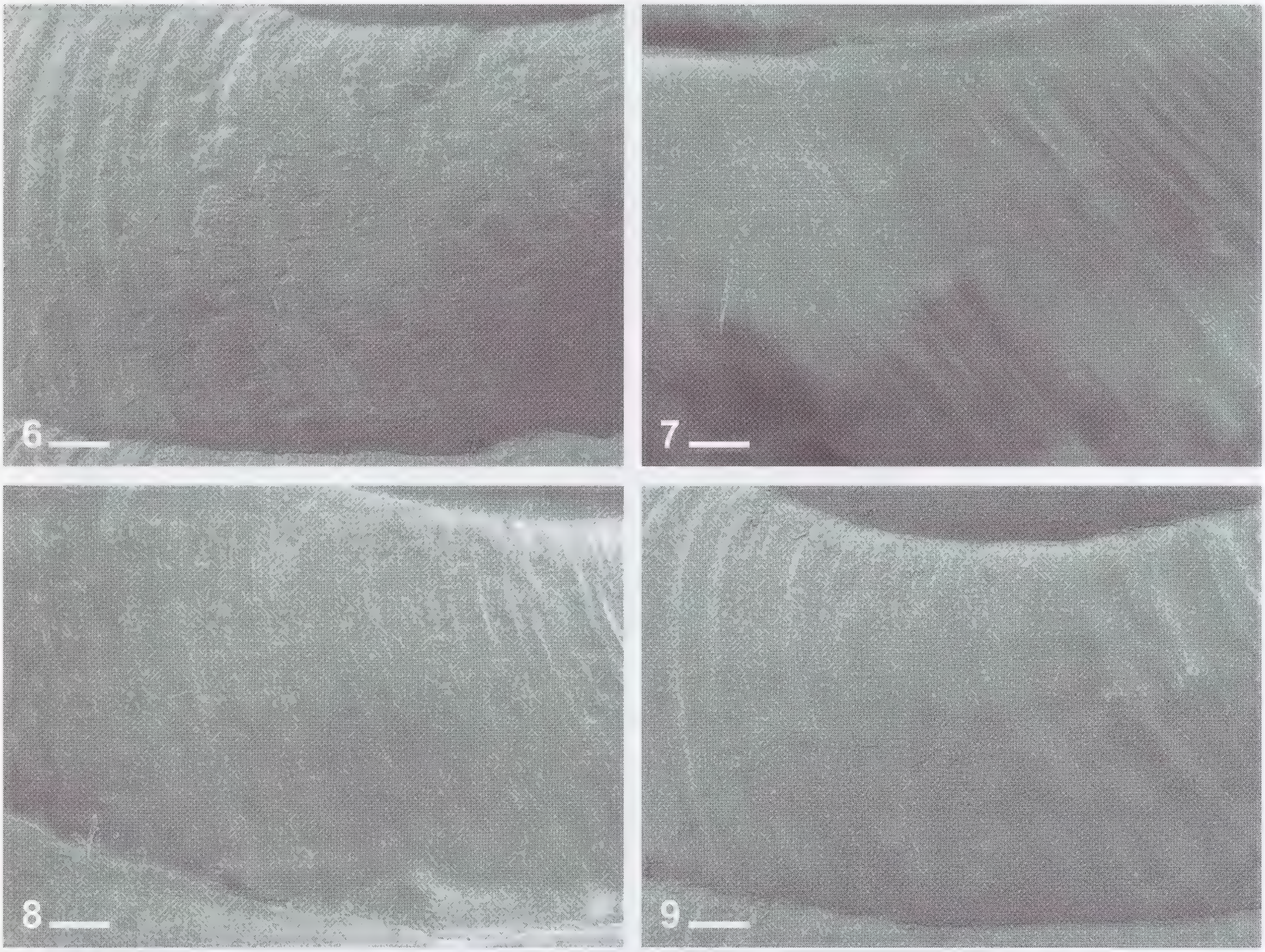
Shell (Fig. 1-9) depressed conical-globular; with 4.5–6 convex whorls; teleoconch with irregular wrinkled growth-ridges, very indistinct incised spiral striae and distinct pits or only with distinct incised spiral striae; whitish above the periphery, with a distinctly limited brownish corneous band; whitish corneous below the periphery; body whorl rounded; aperture almost circular; upper insertion of the peristome usually ± descending; peristome sharp, hardly expanded, with a strong, whitish internal rib; umbilicus minute, almost completely or completely covered by the reflection of the columellar edge.

Remarks The conchological description applies to all forms of the complex. However, the populations can be divided into two series according to shell sculpture. Populations from the islands Psathúra, Skíros, Psará, Síros, Sérifos, Sífnos, Ródos and Cyprus and from Izmir have distinct pits and very indistinct incised spiral striae. In other populations pits are missing, but the incised spiral striae are distinct. The shell structure is apparently constant within populations. Only some old series include both forms, but this is probably the result of confusions. Therefore, in the following descriptions it will be noted only whether a species has a shell sculpture with or without pits.

Distribution (Fig. 14) The *M. rothii* complex is mainly spread on the Aegean Islands from Gökçeada, Límnos and the Northern Sporades in the north to Crete and Ródos in the south. There are some 19th century records of the *M. rothii* complex from the environs of Izmir (see below under additional nominal taxa). Other records from the Turkish mainland (see Hausdorf, 2000a) as well as records from the Greek mainland (Frank, 1976, 1983, 1984, 1988) proved to be wrong. There is also a 19th century record of the *M. rothii* complex from Cyprus (Unger & Kotschy, 1865; ZMH 2907) which has to be confirmed.



Figs 1–5 1–2 *Monacha rothii* (L. Pfeiffer, 1841) **1** Greece, Island Síros (syntype of *H. rothii* L. Pfeiffer ZSM 19960567). **2** Greece, Island Shinoúsa (NHMWK 19229). **3** *Monacha* (*Paratheba*) *pseudorothii* n. sp. Greece, Island Anáfi, Mount Vigla (holotype NHMWE 56449). **4** *Monacha* (*Paratheba*) *maasseni* n. sp. Greece, Island Ródos, Moní Skiádi (holotype NNM). **5** *Monacha* (*Paratheba*) *cretica* n. sp. Greece, Island Kríti, 8 km N of Omalós (holotype NNM). Scale bar = 5 mm.



Figs 6–9 Shell sculpture of the penultimate whorl. **6** *Monacha* (*Paratheba*) *rothii* (L. Pfeiffer, 1841). Greece, Island Síros (ZMH 2904). **7** *Monacha* (*Paratheba*) *pseudorothii* n. sp., Greece, Island Ikaría, Ágios Kírikos towards Therma (paratype ZMH 2905). **8** *Monacha* (*Paratheba*) *maasseni* n. sp. Greece, Island Ródos, Moní Skiádi (paratype NNM). **9** *Monacha* (*Paratheba*) *cretica* n. sp. Greece, Island Kríti, Élos (paratype ZMH 2906). Scale bar = 200 µm.

Monacha (*Paratheba*) *rothii* (L. Pfeiffer, 1841)

Helix Rothii L. Pfeiffer, 1841: 218. Locus typicus: "Syra", Greece.

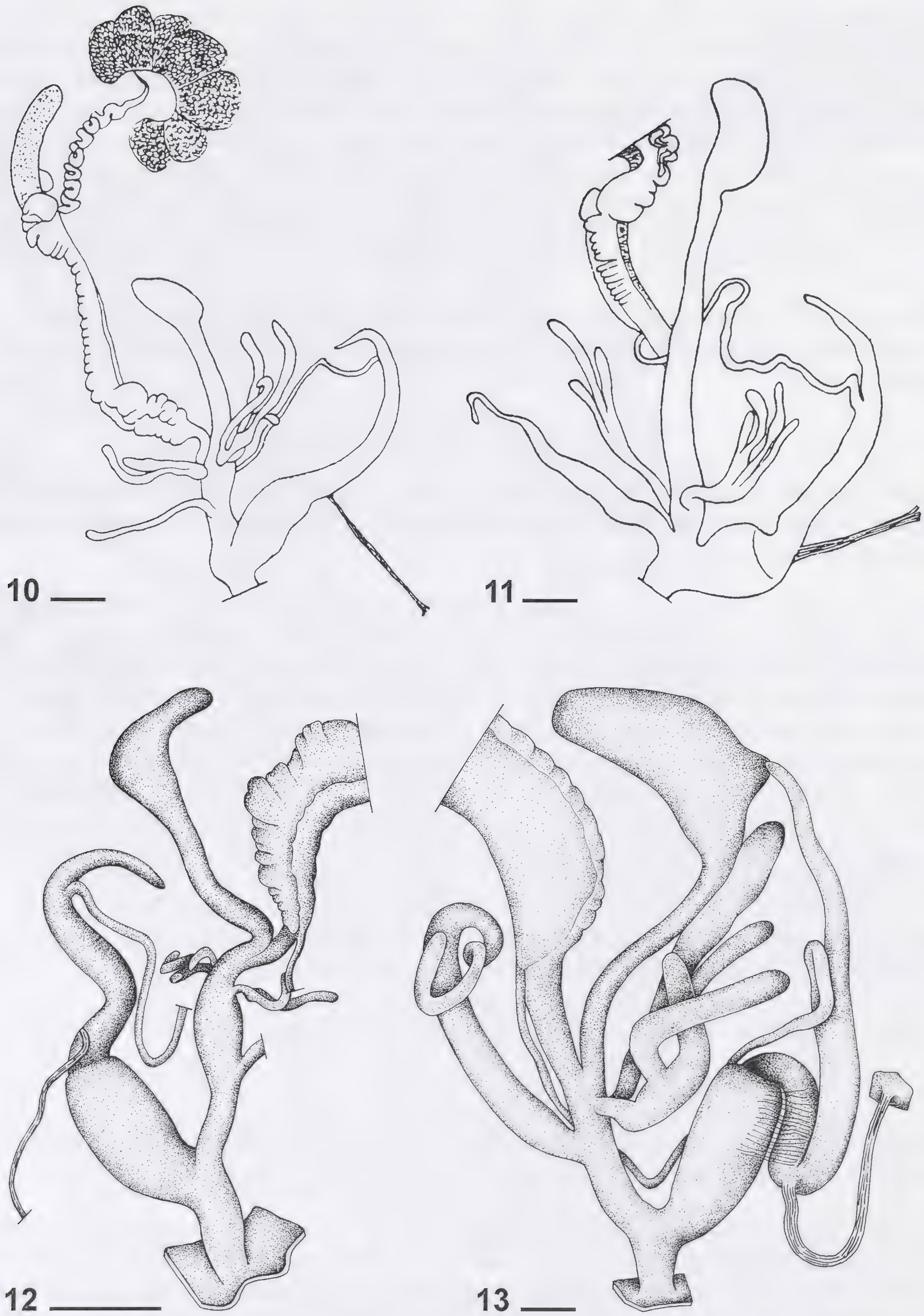
Syntypes Greece, Island Síros, LB14 (ZSM 19960567).

Preserved material Greece, Nomos Kikládes: Island Rínia, LB44 (NHMWK 19253/ NHMWF 740); Island Naxos, Kouros of Apóllonas, LB61 (rehydrated; BAN); Island Shinoúsa, LA68 (NHMWK 19227/ NHMWF 7, NHMWK 19229/ NHMWF 6).

Shell (Fig. 1–2, 6) with or without pits.

Measurements Island Síros (n = 30): D: 9.6-13.1 mm, ø = 11.3 mm; H: 6.7-10.3 mm, ø = 8.0 mm; D/H: 1.27-1.50, ø = 1.40.

Genitalia (Fig. 10) The appendicula is not distinctly divided into sections, but is narrow tube-like. The two glandulae mucosae are slightly ramified. The bursa of the bursa copulatrix is ± rounded triangular. The right ommatophoral retractor crosses with the penial retractor. The measurements of some sections of the genitalia are compiled in Table 1 and the variation of the proportions of some sections of the genitalia is compiled in Table 2.



Figs 10–13 Genitalia. **10** *Monacha* (*Paratheba*) *rothii* (L. Pfeiffer, 1841). Greece, Island Shinoúsa (NHMWF 6; after Fuchs & Käufel 1936: fig. 68). 11 *Monacha* (*Paratheba*) *pseudorothii* n. sp., Greece, Island Anáfi, Mount Vigla (holotype NHMWF 34; after Fuchs & Käufel 1936: fig. 69). 12 *Monacha* (*Paratheba*) *maasseni* n. sp. Greece, Island Ródos, Moní Skiádi (holotype NNM). 13 *Monacha* (*Paratheba*) *cretica* n. sp. Greece, Island Kríti, 8 km N of Omalós (holotype NNM). Scale bar = 2 mm.

Remarks The shells of specimens from the type locality, the Island Síros, have pits, whereas the shells of the anatomically examined specimens from the islands Rínia, Náxos and Shinoússa have no pits. Unfortunately, no preserved specimens of the pitted form from the type locality were available for anatomical investigations. However, the genitalia of specimens from Síros were described and figured by Hesse (1931). The genitalia of specimens of the pitless form agree with these figures except that the epiphallus is relatively shorther than that of the specimen from Síros figured by Hesse (1931). Despite the differences, the specimens from Rínia, Náxos and Shinoússa are preliminarily classified with *M. rothii* (L. Pfeiffer). However, the relationships of these forms will have to be reexamined when preserved adult specimens from Síros are be available.

Distribution (Fig. 14) So far only specimens from the islands of Síros, Rínia, Náxos and Shinoússa have been examined anatomically. *M. rothii* is probably restricted to the Cyclades.

Monacha (*Paratheba*) *pseudorothii* n. sp.

Holotype Greece, Nomos Kikládes: Island Anáfi, Mount Vigla, LA82 (NHMWE 56449/ NHMWF 34, leg. F. Werner 1934, measurements: D = 14.2 mm, H = 10.1 mm, specimen to Fuchs & Käufel, 1936).

Paratypes Greece, Nomos Sámos: Island Ikaría, Ágios Kírikos towards Therma, MB36 (det. anat.; BAN, specimens to Bank & Maassen, 1998; ZMH 2905); Island Ikaría, trifurcation Mavrikato/Therma/Ágios Kírikos 1 km towards Therma, MB36 (BAN, specimens to Bank & Maassen, 1998); Island Ikaría, Ágios Kírikos, MB36 (NHMWK 19248, specimens to Fuchs & Käufel, 1936, NHMWK 19269, specimens to Fuchs & Käufel, 1934). – Nomos Dodekánissa: Island Kínaros, MA39 (det. anat.; NHMWF 445, specimen to Fuchs & Käufel, 1936); Island Ofidoússa, MA24 (det. anat.; NHMWK 19142, NHMWK 56448/ NHMWF 454, specimen to Fuchs & Käufel, 1936); Island Astipálea, Ágios Ioannis, MA34 (det. anat.; GIU); Island Astipálea, castle of Astipálea, MA44 (det. anat.; BAN). – Nomos Kikládes: Island Anáfi (SMF 69109, 98750); Island Anáfi, old way from the harbour to the village, LA82 (LIE); Island Anáfi, Anáfi, LA82 (NHMWK 19247, specimen to Fuchs & Käufel, 1936); Island Anáfi, E of the village, LA82 (LIE); Island Anáfi, monastery, LA92 (det. anat.; GIU); Island Anáfi, Kalamiotissa, LA92 (det. anat.; GIU).

Type locality Greece, Nomos Kikladés: Island Anáfi, Mount Vigla, LA82.

Shell (Fig. 3, 7) without pits.

Measurements Island Anáfi (n = 10): D: 11.7-14.3 mm, ø = 12.8 mm; H: 7.9-10.1 mm, ø = 8.9 mm; D/H: 1.41-1.51, ø = 1.44.

Genitalia (Fig. 11) The appendicula is not distinctly divided into sections, but is broadening basally. The two glandulae mucosae are slightly ramified. The bursa of the bursa copulatrix is ± rounded triangular. The right ommatophoral retractor crosses with the penial retractor. The measurements of some sections of the genitalia are compiled in Table 1 and the variation of the proportions of some sections of the genitalia is compiled in Table 2.

Remarks *M. pseudorothii* differs from *M. rothii* in the lower epiphallus to flagellum ratio, the relatively longer, basally broadening appendicula which inserts at the distal end of the vagina and the insertion of the glandulae mucosae at the distal section of the vagina.

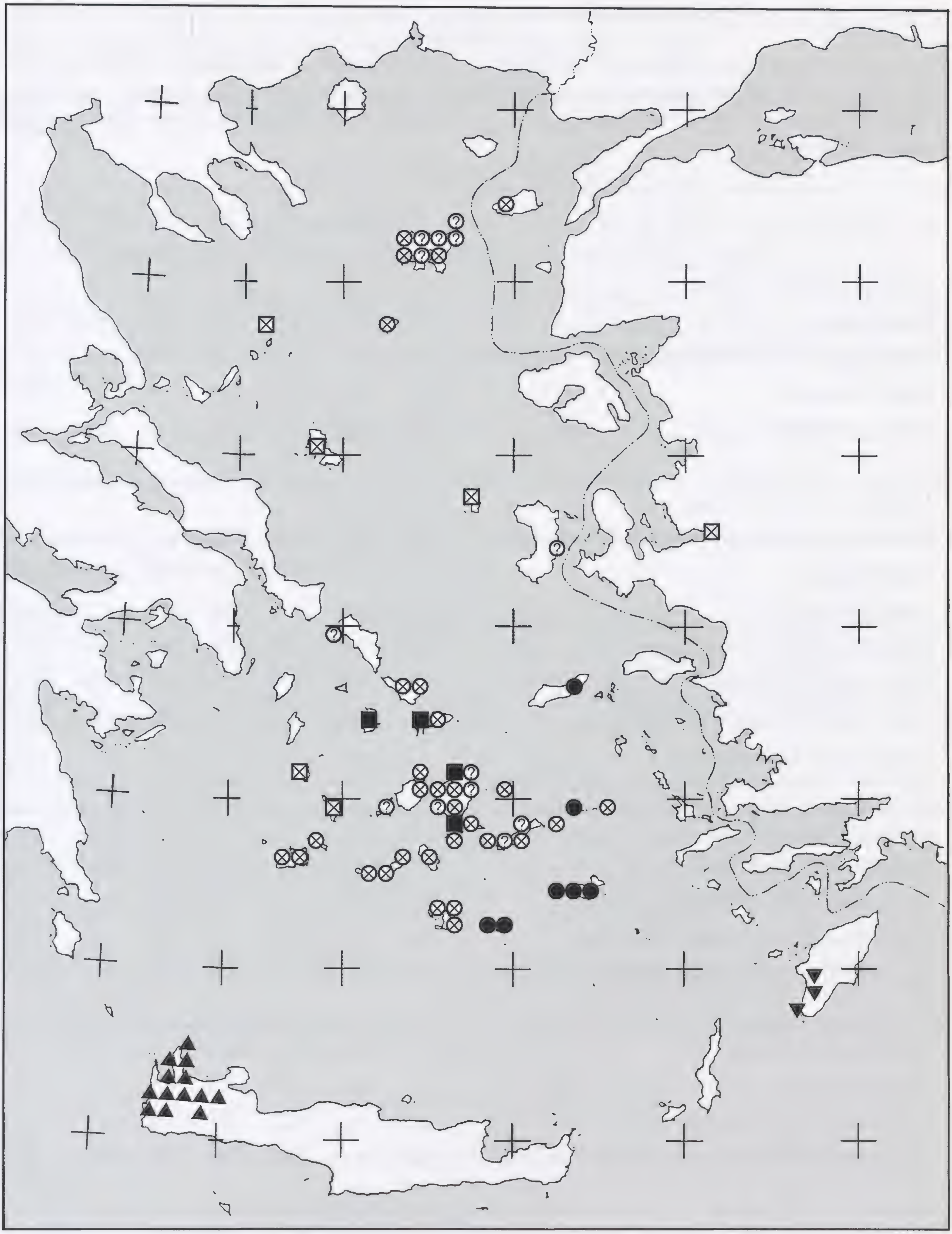


Fig. 14 Distribution of *Monacha* (*Paratheba*) *rothii* (L. Pfeiffer) (det. anat.) ■ , *Monacha* (*Paratheba*) *pseudorothii* n. sp. (det. anat.) ● , *Monacha* (*Paratheba*) *maasseni* n. sp. ▼ , *Monacha* (*Paratheba*) *cretica* n. sp. ▲ , anatomically unknown pitted forms ☒, anatomically unknown pitless forms ⊗ and additional literature (Bar & Butot, 1986; Cameron, Mylonas & Vardinoyannis, 2000; Fuchs & Käufel, 1934; Reischütz, 1986; Martens, 1889; Mylonas, 1982; Vardinoyannis, 1994) records of forms of the *M. rothii* complex ?⃝ (UTM-grid, 10 km - squares).

TABLE 1

Measurements of some sections of the genitalia of the species of the *Monacha* (*Paratheba*) *rothii* complex (in mm). Abbreviations: ap = appendicula; ep = epiphallus; fl = flagellum; p = penis; v_{ap} = vagina up to the base of the appendicula; v_{gm} = vagina up to the glandula mucosae; v_t = total length of the vagina

	p	ep	fl	ap	v_{ap}	v_{gm}	v_t
Monacha rothii (L. Pfeiffer)							
Island Rínia	1.6	3.1	1.4		1.6	2.5	2.8
Island Naxos, Kouros of Apóllonas (rehydrated)	1.3	4.5	2.1	2.2	1.0		2.0
Island Shinoúsa	2.9	5.7	2.3	4.6	1.5	3.3	3.5
Island Shinoúsa	2.4	4.7	2.0	3.2	1.4	2.3	2.5
Monacha pseudorothii n. sp.							
Island Ikaría, Ágios Kírikos towards Therma	2.2	6.6	3.2	10.0	0.1	2.4	5.1
Island Kínaros	1.3	3.0	2.2	4.6	0.2	0.7	2.8
Island Ofidoússa	1.8	4.6	2.3	5.1	0.2	1.0	4.0
Island Astipálea, Ágios Ioannis	2.4	5.6	3.0	6.2	0.0	1.0	5.7
Island Astipálea, castle	3.2	8.4	6.1	12.0	0.3	1.4	6.8
Island Anáfi, Mount Vigla (holotype)	2.6	7.5	3.8	9.1	0.0	0.9	6.3
Island Anáfi, Kalamiotissa	1.5	2.8	1.9	3.6	0.0	0.7	2.5
Monacha maasseni n. sp.							
Island Ródos, Moní Skiádi	2.7	3.7	2.2		1.7	3.4	3.8
Island Ródos, Moní Skiádi (subadult)	1.0	2.0	1.3	1.5	0.8	1.5	1.7
Island Ródos, Moní Skiádi (subadult)	0.9	1.8	1.4	1.2	1.2	2.2	2.5
Island Ródos, Moní Skiádi (subadult)	1.0	2.1	1.1	1.1	1.5	2.2	2.6
Monacha cretica n. sp.							
Island Kríti, 8 km north of Omalós (holotype)	3.1	6.5	3.7	8.5	1.5	2.2	3.0
Island Kríti, 8 km north of Omalós	3.0	6.1	4.2	13.0	1.5	2.6	3.5
Island Kríti, 8 km north of Omalós	3.6	6.2	3.9	10.5	1.7	2.7	3.2
Monacha sp.							
Island Límnos, Kastro (subadult)	1.1	1.8	1.4	1.0	1.0	2.0	2.2

Distribution (Fig. 14) So far there are anatomically confirmed records of *M. pseudorothii* from the islands Ikaría, Kínaros, Astipálea, Ofidoússa and Anáfi.

Etymology Because the shells of this species are indistinguishable from *M. rothii* (L. Pfeiffer).

Monacha (*Paratheba*) *maasseni* n. sp.

Holotype Greece, Nomos Dodekánissa: Island Ródos, Moní Skiádi, NV78 (NNM, leg. W. J. M. Maassen 27.04.1979, measurements: D = 11.5 mm, H = 7.8 mm).

Paratypes Greece, Nomos Dodekánissa: Island Ródos, Kattavía, south of the Hazda, NV67 (SMF 98754); Moní Skiádi, NV78 (det. anat; MAA; NNM, specimens to Maassen, 1981); 1 km NE of Lahania, NV78 (MAA); Appolakkiá, NV79 (NHMW 77020, specimens to Frank, 1997).

Type locality Greece, Nomos Dodekánissa, Island Ródos: Moní Skiádi, NV78.

Shell (Fig. 4, 8) with pits.

Measurements Island Ródos, Moní Skiádi (n = 20): D: 9.4-11.5 mm, ø = 10.4 mm; H: 6.2-8.0 mm, ø = 7.2 mm; D/H: 1.36-1.52, ø = 1.44.

Genitalia (Fig. 12) The appendicula is not distinctly divided into sections, but is usually broadening basally. The two glandulae mucosae are slightly ramified. The bursa of the bursa copulatrix is ± rounded triangular or elongate-oval. The measurements of some sections of the genitalia are compiled in Table 1 and the variation of the proportions of some sections of the genitalia is compiled in Table 2.

Remarks *M. maasseni* differs from *M. rothii* in the lower epiphallus to flagellum ratio and from *M. pseudorothii* in the insertion of the relatively shorter appendicula at the middle section of the vagina and the insertion of the glandulae mucosae near the proximal end of the vagina (as in *M. rothii*) (see Table 2). The shell of *M. maasseni* differs from that of *M. pseudorothii* in the presence of pits, but cannot be distinguished from forms of *M. rothii* with pits.

Distribution (Fig. 14) *M. maasseni* is known only from the southern part of Ródos.

Etymology This species in named in honor of Wim J. M. Maassen, Duivendrecht, who collected the species alive and made the dissections.

Monacha (*Paratheba*) *cretica* n. sp.

Helix (*Cartusiana*) *rothi* [sic] var. *psiloritana* "Maltzan" Martens, 1889: 186 [nomen nudum].

Holotype Greece, Island Kríti, Nomos Haniá: 8 km N of Omalós, GE61 (NNM, leg. W. J. M. Maassen April 1987, measurements: D = 9.9 mm, H = 6.7 mm).

Paratypes Greece, Island Kríti, Nomos Haniá: Élos, GE31 (ZMH 2906); Merádha, Kastelos, GE32 (NHMWE 28354); 0.5 km N of Kakópetros, GE52 (REI); 2 km S of Kakópetros, GE52 (MAA); 8 km N of Omalós, GE61 (det. anat.; MAA; NNM); Omalós, GE61 (NHMW 434).

TABLE 2

Comparison of the ratios of some sections of the genitalia of the species of the *Monacha* (*Paratheba*) *rothii* complex. Abbreviations: ap = appendicula; ep = epiphallus; fl = flagellum; p = penis; v_{ap} = vagina up to the base of the appendicula; v_{gm} = vagina up to the glandula mucosae; v_t = total length of the vagina

	ep: p	ep: fl	ep: ap	ep: v_t	v_t: v_{ap}	v_t: v_{gm}
M. rothii (L. Pfeiffer)	1.9-3.5	2.2-2.5	1.2-2.0	1.1-2.3	1.8-2.3	1.1
M. pseudorothii n. sp.	1.9-3.0	1.4-2.1	0.7-0.9	1.0-1.3	14.0-∞	2.1-7.0
M. maasseni n. sp.	1.4-2.1	1.3-1.9	1.3-1.9	0.7-1.2	1.7-2.2	1.1-1.2
M. cretica n. sp.	1.7-2.1	1.5-1.8	0.5-0.8	1.7-2.2	1.9-2.3	1.2-1.4
M. sp. (Límnos)	1.6	1.3	1.8	0.8	2.2	1.1

Type locality Greece, Island Kríti, Nomos Hania: 8 km N of Omalós, GE61.

Shell (Fig. 5, 9) without pits.

Measurements Island Kríti: 8 km N of Omalós (n = 20): D: 8.6–11.0 mm, ø = 9.9 mm; H: 5.9–7.8 mm, ø = 7.0 mm; D/H: 1.32–1.54, ø = 1.43.

Genitalia (Fig. 13) The long basal section of the appendicula is almost cylindrical and passes gradually into the short, narrow apical section. The two glandulae mucosae are bifid. The bursa of the bursa copulatrix is ± rounded triangular or elongate-oval. The right ommatophoral retractor crosses with the penial retractor. The measurements of some sections of the genitalia are compiled in Table 1 and the variation of the proportions of some sections of the genitalia is compiled in Table 2.

Remarks *M. cretica* differs from *M. rothii* in the lower epiphallus to flagellum ratio and the relatively longer appendicula, from *M. pseudorothii* in the higher epiphallus to vagina ratio, the insertion of the appendicula at the middle section of the vagina and the insertion of the glandulae mucosae near the proximal end of the vagina and from *M. maasseni* in the relatively longer appendicula and relatively shorter vagina (see Table 2). The shell of *M. cretica* differs from that of *M. maasseni* in the lack of pits, but cannot be distinguished from *M. pseudorothii* or pitless forms of *M. rothii*.

Distribution (Fig. 14) *M. cretica* is known only from the westernmost part of Crete (see also Vardinoyannis, 1994).

Etymology Because the species is endemic in Crete.

Monacha (*Paratheba*) sp.

Preserved material Greece, Nomos Lésvos: Island Límnos, Kastro, LE31 (NHMWK 19252/ NHMWF 741); Ag. Charalambos, LE63 (REI, specimen to Reischütz, 1986: 96, fig. 7a).

Remarks Two subadult, pitless specimens of the *M. rothii* complex from the Island Límnos are characterized by a relatively long flagellum (Table 1, 2). They resemble *M.*

maasseni n. sp. from Ródos in this respect. However, they differ from that species in the absence of pits. Preserved adult specimens from Límnos are necessary for a clarification of the relationships of this form.

Additional nominal taxa:
Helix Rothi var. *obsita* Mousson, 1854a: 372. Locus typicus: "Smyrne", Turkey.
Helix Rothi var. *obsita*, – Mousson, 1854b: 26, fig. 4.
Helix Draxleri Kobelt, 1878: 39, pl. 160 fig. 1635. Locus typicus: "Smyrna", Turkey.
Helix rothi var. *imperforata* Martens, 1889: 181. Locus typicus: "Smyrna", Turkey.

Lectotype of H. rothii var. *obsita* Turkey, Vilayet Izmir: Izmir, NC15 (ZMZ 508220a).
Paralectotype of H. rothii var. *obsita* Turkey, Vilayet Izmir: Izmir, NC15 (ZMZ 508220b).

Lectotype of H. draxleri and *H. rothi* var. *imperforata* Turkey, Vilayet Izmir: Izmir, NC15 (SMF 6228c, specimen to Kobelt, 1878: pl. 160 fig. 1635).

Remarks The types of *Helix Rothi* var. *obsita* Mousson from Izmir (= Smyrna) belong to the pitted form. The lectotype of *Helix Draxleri* belongs also to the pitted form and allegedly also comes from Smyrna. However, Kobelt (1878) obviously thought that this was an error and that the specimen came from Syra (= Island Síros). The name *H. Draxleri* was published in the synonymy of *H. rothii* and has never been used as a valid name. Therefore, this name is not available (Art. 11.6 ICZN). However, Martens (1889) based the name *Helix rothi* var. *imperforata* Martens on the figure given by Kobelt (1878: fig. 1635). The occurrence of the *M. rothii* complex in the environs of Izmir has not been confirmed since. Thus, it is unclear whether a form of the complex actually lives there, or whether the old records are based on confusion of locality data or on specimens from the debris of the Aegean Sea (Hausdorf, 2000a). The types of the listed names cannot be distinguished from *M. rothii* (L. Pfeiffer). If they come from the Cyclades, it is likely that they are conspecific with that species. But if they are actually from the surroundings of Izmir, they might represent a distinct species which would have to bear the name *M. obsita* (Mousson).

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TWO SPECIES OF *GYRAULUS* (PULMONATA: PLANORBIDAE) NEW TO THE BRITISH PLEISTOCENE

R.C. PREECE[1]

Abstract A specimen of Gyraulus riparius *(Westerlund) has been detected in a sample of fossiliferous fluvial silt of late Middle Pleistocene age from new sections exposed in the well knoswn interglacial deposits at Histon Road, Cambridge. Several specimens of* Gyraulus rossmaessleri *(Auerswald) were recovered, together with a restricted fauna of other molluscs, from organic silts associated with an intraformational ice-wedge cast within fluvial gravels at Baston, Lincolnshire. These silts probably accumulated in a thaw pool that existed during an extremely cold episode in the middle of the last (Devensian) cold stage, a conclusion supported by other fossils and by a radiocarbon date of 31,570 +/- 510 yr BP. Neither species lives in Britain today and neither had previously been recorded from the British Pleistocene.*

Key words Gyraulus riparius, Gyraulus rossmaessleri, *Histon Road, Cambridge, Baston, Lincolnshire, Pleistocene, Devensian*

INTRODUCTION

The purpose of this short paper is to place on record the occurrence of two species of freshwater pulmonate snails that have hitherto not been found either living in the British Isles today or found as fossils in the British Pleistocene. Both are planorbids belonging to the genus *Gyraulus* and both are the only members of the subgenus *Lamorbis*, distinguished from other subgenera on the basis of differences in the male copulatory organ, especially the club-shaped penis sheath (Meier-Brook, 1964; 1983). The details and context of their occurrence are given below.

THE NEW RECORDS

Gyraulus riparius (Westerlund, 1865)

The shell of this species is small and delicate, rarely exceeding 2.3 mm in diameter and 0.6 mm in height. It is discoidal with three flattened whorls and resembles a young *Hippeutis complanatus* in shape but the surface is silky rather than shiny (Gittenberger *et al.*, 1998, figs 330–332).

A single sub-adult specimen of *G. riparius*, measuring <2 mm in diameter (Fig. 1), was recovered from a sediment sample collected from new sections exposed during the recent re-development of the site at Histon Road, Cambridge (TL 444611). Pleistocene sediments have been known at this site for over fifty years and detailed analyses of the plant and molluscan assemblages have been undertaken (Hollingworth *et al.*, 1950; Walker, 1953; Sparks & West, 1959). The molluscan assemblages from the new sections, which are no more than 200 m from the earlier sections, were relatively rich (25 aquatic taxa, 12 terrestrial) and similar to those already reported from the site, although a few species (e.g. *Marstoniopsis scholtzi*) found previously were not recovered in the new samples. These assemblages include thermophilous species, which reflect temperate conditions. Associated planorbids consisted of *Anisus leucostoma* and *Planorbis planorbis* in high numbers and *Anisus vortex, A. vorticulus, Bathyomphalus contortus, Gyraulus crista, Hippeutis complanatus* and *Segmentina nitida*. Other associated aquatic gastropods

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[1] Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ

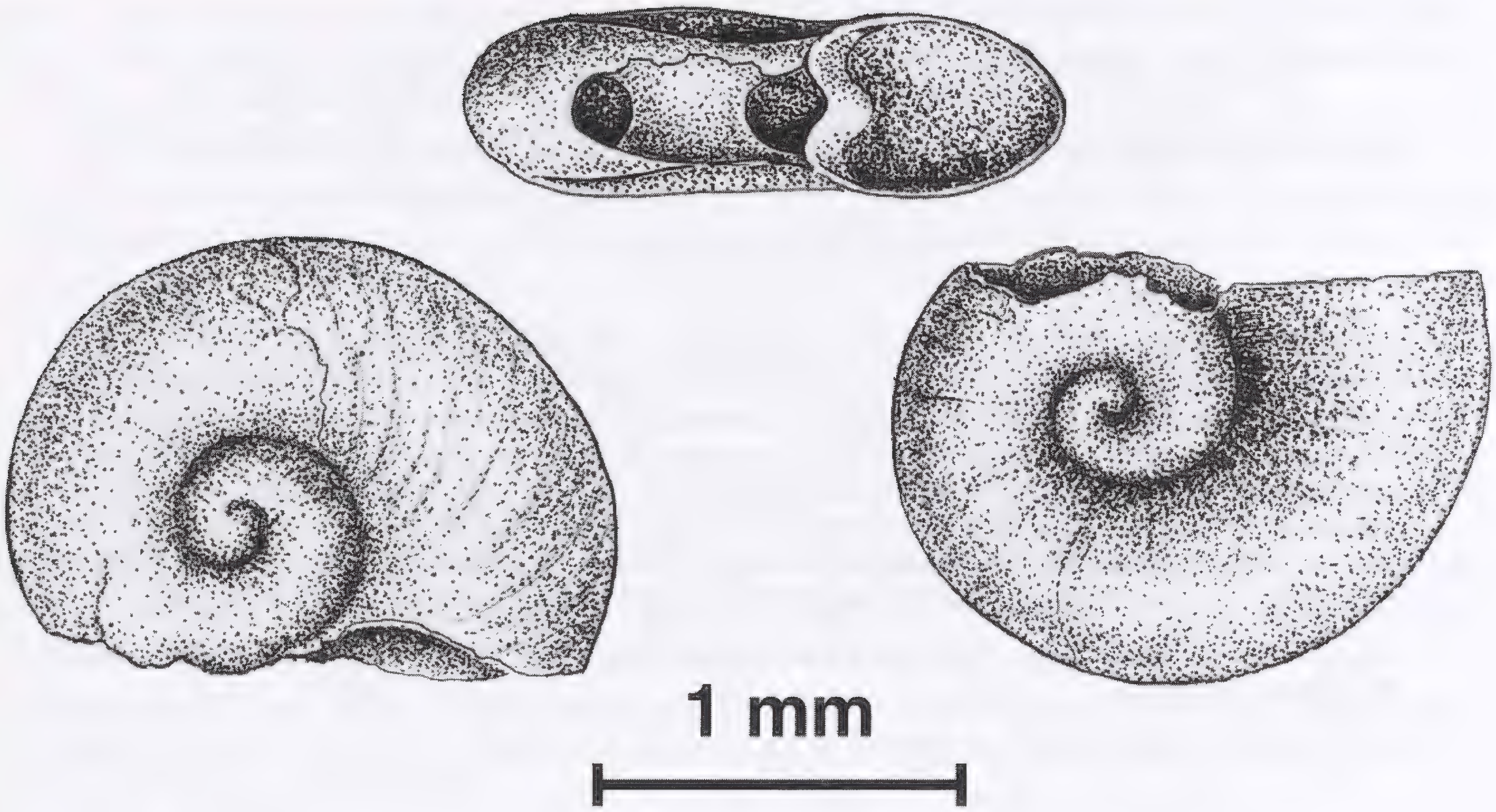

Fig. 1 *Gyraulus riparius* from interglacial silts at Histon Road, Cambridge.

included *Valvata cristata*, *V. piscinalis*, *Bithynia tentaculata*, *Lymnaea palustris*, *L. truncatula* and *L. peregra*. Complete details of the new sections at Histon Road, together with their palaeontology, are provided by Boreham (2002).

The Pleistocene deposits form part of the Third Terrace of the River Cam and are mostly fluvial organic silts that fill a channel, the base of which occurs at about 3 m OD. The silts are between 6 to 8 m in thickness and are both underlain and overlain by gravels, which take the ground surface to about 13 m OD. Most temperate stage organic deposits from fluvial contexts appear to cover only the early parts of the interglacial but those at Histon Road are unusual since most of them accumulated towards the end of an interglacial period. Pollen spectra reflecting mixed oak forest of the early temperate sub-stage occur only at depth; most of the upper sediments are rich in *Carpinus* and appear to have formed during the late temperate sub-stage, although re-working appears to have been significant at the site (Sparks & West, 1959). The sample yielding the *G. riparius* appeared to come from the transition from the late temperate to the post-temperate sub-stage, well after the thermal optimum of the interglacial. For many years, the organic sediments at Histon Road were thought to belong to the Last (Ipswichian) Interglacial but it now seems likely, largely on the basis of vertebrate evidence (especially the occurrence of horse), that some belong to an earlier stage, perhaps that equivalent to part of oxygen isotope stage 7 (Boreham, 2002).

G. riparius has a large range extending from the Urals, southwards to the Caspian and westwards into southern Scandinavia, Germany and the Netherlands (Meier-Brook, 1983). It has never previously been found in the British Isles either living or as a fossil. Little is known of its ecological requirements, but it often occurs in clear, stagnant freshwater with a rich vegetation. It does not appear to be able to withstand desiccation or brackish water and often occurs, as at Histon Road, only in small numbers. In the Netherlands it occurs in the late Lower Pleistocene and is also known from the Holocene (Gittenberger *et al.*, 1998).

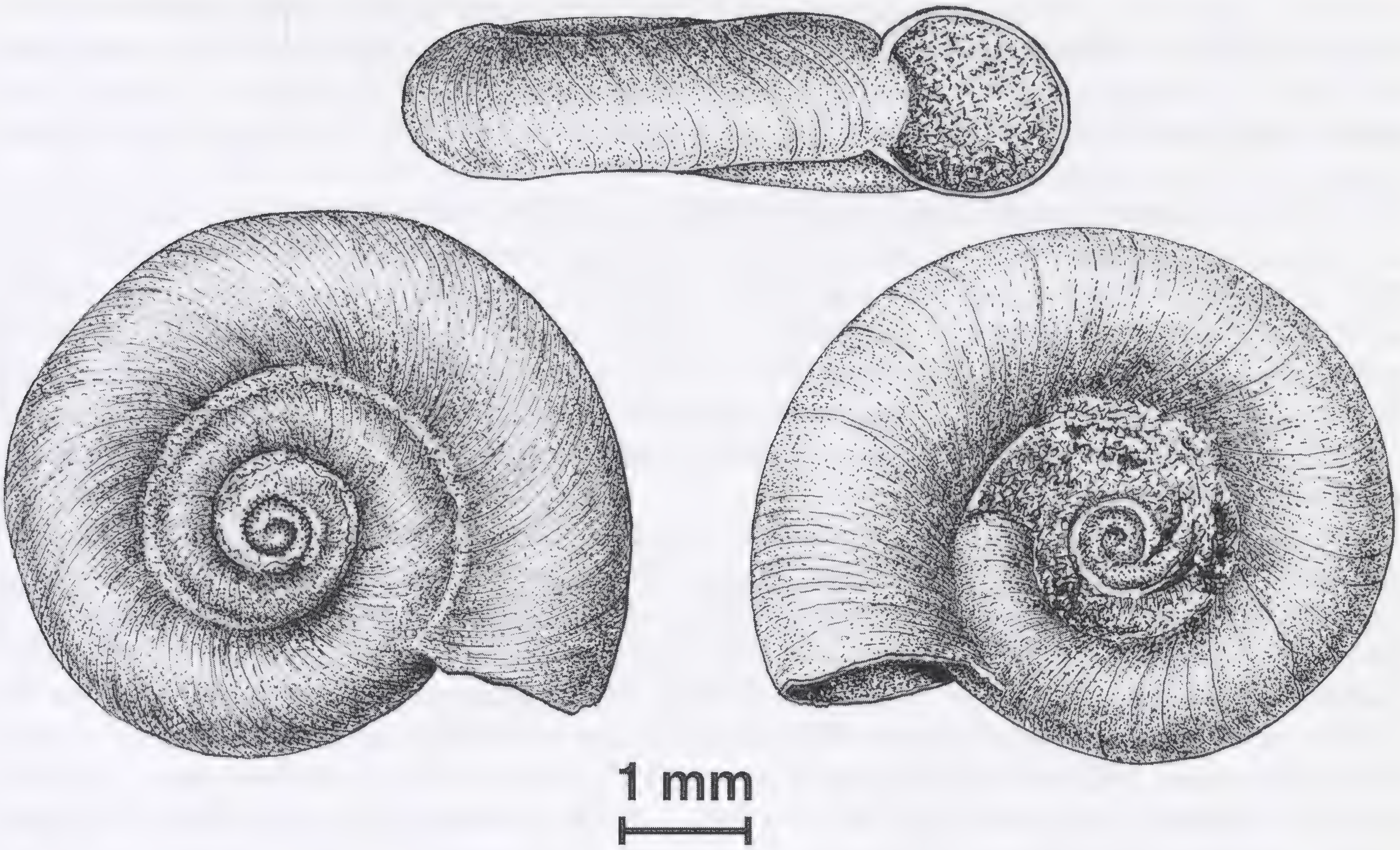

Fig. 2 *Gyraulus rossmaessleri* from an organic silt associated with an ice-wedge cast at Baston, Lincolnshire.

Gyraulus rossmaessleri (Auerswald, 1851)

The taxonomy of this species is complicated because for many years it was considered little more than a stunted form or subspecies of *G. acronicus* (=*gredleri*) but its specific distinctness was upheld by Meier-Brook (1964). All records made before this date should therefore be treated with caution. The shell is far larger than that of *G. riparius* but seldom exceeds 4 mm in diameter. It is similar to *G. laevis* in general form but less deeply umbilicate with shallower sutures and more rounded whorls that are never angulated or keeled (Meier-Brook, 1964, figs 4–5; Gittenberger *et al.*, 1998, figs 327–329). The aperture has a characteristic thickened lip and the shell may often bear growth irregularities, perhaps reflecting the ephemeral nature of its habitat.

One adult shell (Fig. 2) and several juveniles of *G. rossmaessleri* were recovered from a sample (G141) of an organic deposit within First Terrace Gravels of the River Welland at Gibbons Pit, Baston, Lincolnshire (TF 119142 to TF 128130). The organic deposit was associated with an intraformational ice-wedge cast that had developed within coarse horizontally-bedded gravels (Briant, 2002). The existence of the ice-wedge cast indicates regional permafrost and its complex form suggests multiple episodes of growth. A radiocarbon date of 31,570 ± 510 yr BP (AA-41735) obtained from this organic deposit shows that it formed during the Middle Devensian, about 12,000 years before the last glacial maximum. It is likely that the organic sediments accumulated in a shallow thaw-pool during the spring and summer months. Oogonia of stoneworts (Characeae) were abundant and seeds of *Potamogeton* sp. and *Ranunculus* (subg. *Batrachium*) were also detected (Briant, 2002). Further indications of the severity of the climate come from the beetle assemblage recovered from the same deposit. This included four cold-adapted species (*Helophorus obscurellus, Holoboreaphilus nordenskioeldi, Boreophilus henningianus, Simplocaria metallica*) that no longer live in the British Isles, which suggest that mean July temperatures were 9–11°C and mean January temperatures were below -23°C (G.R. Coope, pers. comm.). Three other species of aquatic molluscs (*Lymnaea truncatula*, *Lymnaea palustris, Anisus leucostoma*) and five terrestrial taxa (*Catinella/Succinea*, cf. *Oxyloma pfeifferi, Vertigo* sp., *Pupilla muscorum* and *Columella columella*) were associated with the *G. rossmaessleri*. These are all hardy species that were widespread during cold stages (Holyoak, 1982). Of these only *C. columella*, which has a modern arctic-alpine range, no longer lives in Britain.

G. rossmaessleri is extinct in the British Isles but it is known from a number of countries in central and eastern Europe but it does not extend into Asia (Meier-Brook, 1983). On the continent *G. rossmaessleri* is a specialist species characteristic of temporary ditches and pools, which appear on floodplains each spring following snow melt. In these ephemeral water-bodies *G. rossmaessleri* is able to complete its life history extremely quickly before the pools dry up again in summer. In such habitats, where the vegetation often consists of terrestrial plants, *Anisus leucostoma* and *Pisidium obtusale* are frequent associates (Meier-Brook, 1961).

The fossil history of *G. rossmaessleri* is not well known but in The Netherlands it occurred during cold periods in the Lower Pleistocene (Tiglian-Bavelian) and in the Late Pleistocene it occurs in sediments dating either from the late (post-trangressional) phase of the Eemian (last interglacial) or from an Early Weichselian (=Devensian) interstadial, possibilities that here cannot be distinguished using pollen analysis. Most of the Dutch records can be securely attributed to the last cold stage and were also recovered from sediments believed to have accumulated in thaw-pools (T. Meijer, pers. comm.). However, these were developed in 'wet loess' of late Weichselian age and are therefore rather younger than those at Baston. Elsewhere, it is possible that *G. rossmaessleri* has been confused with *G. laevis*, which occurs commonly in the Pleistocene in rather similar depositional environments.

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LABORATORY PROPAGATION AND CULTURE OF JUVENILES OF THE ENDANGERED FRESHWATER MUSSEL *MARGARITIFERA AURICULARIA* (SPENGLER, 1793)

R. ARAUJO[1], M. QUIRÓS[2] & M.A. RAMOS[1]

Abstract *We infested three fish species, blenny (*Salaria fluviatilis*), Adriatic sturgeon (*Acipenser naccarii*) and gambusia (*Gambusia holbrooki*), with glochidia of the endangered freshwater mussel Margaritifera auricularia at different holding temperatures, and developed a system to grow and maintain cultured juvenile mussels. The sturgeon and blenny were successfully infested, although these fish sloughed the glochidia in the 24°C experiment. Release of juveniles began 30 days post-infestation for sturgeon and 31 days post-infestation for blennies, and excystment occurred over 8 and 10 days, respectively. The total number of juveniles cultured was 2,562. Although the mortality rate was high, juveniles were maintained alive for at least 4 weeks in the four test tanks. In the most successful tank, 13 juveniles were found after 6 weeks (39 days) of culture. Maximum dimensions for juveniles after culture were: length= 325 µm, width= 250 µm, height = 500 µm, indicating a mean increase of 51% in length, 60% in height and 23% in width.*

INTRODUCTION

Among the European freshwater mussels, *Margaritifera auricularia* is by far the most endangered species, currently living only in Spain (Canal Imperial, Canal de Tauste and Ebro River) and possibly in Morocco (Araujo & Ramos, 2000a). Although there has been a dramatic increase in published information on this species during the last decade (Araujo & Ramos, 2001), captive propagation for restocking, as recommended in the European Action Plan (Araujo & Ramos, 2001), has not been implemented.

Several papers have been published in the United States on captive breeding of freshwater mussels (Hudson & Isom, 1984; Yeager, Cherry & Neves, 1994; Gatenby, Neves & Parker, 1996; Gatenby, Parker & Neves, 1997; O'Beirn, Neves & Steg, 1998), but in Europe, only preliminary experiments on rearing juveniles of the endangered species *M. margaritifera* can be found (Buddensiek, 1995; Harsányi, 1999; Hruska, 1999).

The reproductive period of *M. auricularia* was previously studied (Grande, Araujo & Ramos, 2001). The successful production of juveniles of *M. auricularia* in *Acipenser baeri* and *Salaria fluviatilis* has been achieved (Araujo & Ramos, 2000b; Araujo, Bragado & Ramos, 2001) and gambusia has been recommended for captive breeding by López & Altaba (2000). In this study, we sought to improve upon these first experiments by: 1) using other fish species, 2) increasing the number of specimens, 3) testing different holding temperatures, and 4) developing a system to grow and maintain the juvenile mussels. Results could be applied in aquaculture facilities connected to the Ebro River (the natural habitat of *M. auricularia*), in order to rear thousands of juveniles for release into protected reserves.

MATERIAL AND METHODS

FISH INFESTATION

The experiment was conducted in the aquaculture facilities at Escuela Técnica Superior de Ingenieros Agrónomos (Universidad Politécnica de Madrid. Spain). Three

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1 Department of Biodiversity and Evolutionary Biology. Museo Nacional de Ciencias Naturales (CSIC). José Gutiérrez Abascal 2. 28006 Madrid. Spain. e-mail: rafael@mncn.csic.es
2 Department of Animal Production. Universidad Politécnica de Madrid. E.T.S. I. Agrónomos. Madrid. Spain.

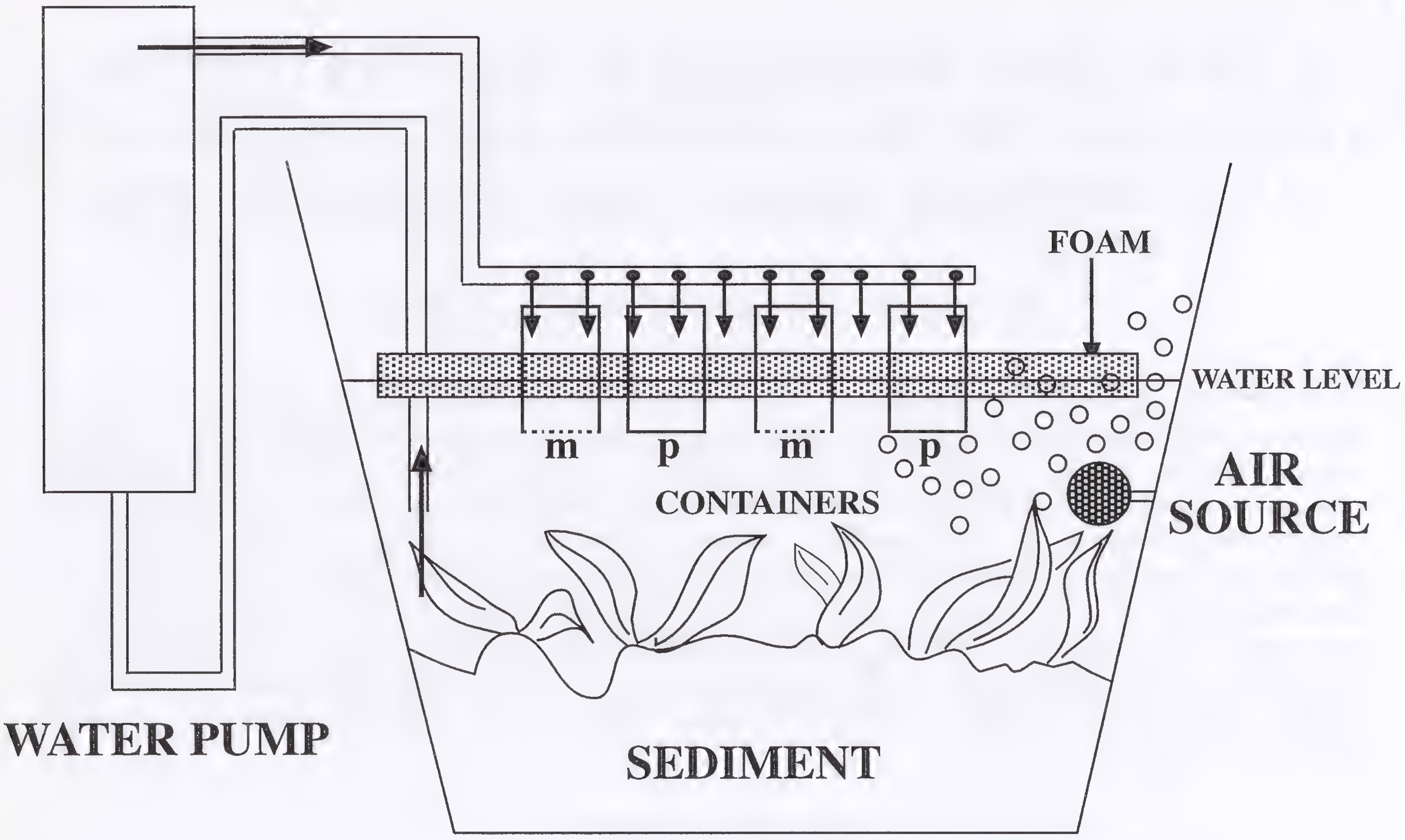

Figure 1 Detail of the culture tank. m= meshed bottom container. p= plastic bottom container.

fish species were used: 14 specimens of blenny (*Salaria fluviatilis*), 15 Adriatic sturgeon (*Acipenser naccarii*) and 9 gambusia (*Gambusia holbrooki*). Sturgeon were obtained from the fish hatchery at Riofrío (Granada, Spain), blennies from the Centro de Experimentación Piscícola El Palmar (Valencia, Spain), and gambusia from an irrigation pond in Madrid (Spain). Fish were maintained at two temperatures (see below) in aerated 200 litre tanks in a recirculating well-water system equipped with biological and mechanical filtration. They were fed frozen mosquito larvae daily. We used ambient light levels for the photoperiod regime.

Ten gravid specimens of *Margaritifera auricularia* (Spengler) were collected at the Canal Imperial (Zaragoza, Spain) in February 2001, and maintained in two aquaria: six specimens in water from the Canal Imperial, and four specimens in Canal Imperial water with 10 cm of sediment.

For induced infestations, mature glochidia were collected with a pipette through the exhalant aperture of the gravid mussels and rinsed with aerated water for 20 min in a glass jar containing the isolated fish. Once infested, the fish were maintained in the aerated tanks, but were isolated from the recirculating system. They were fed for the first 28 days. During this period, they were regularly anaesthetized with 3-Aminobenzoic Acid Ethyl Ester (MS222) to examine the occurrence of glochidia in the gills.

Two different experiments were conducted:

- Low temperature. Infested fish were maintained in four tanks: A1: 6 blennies infested on March 12. A2: 2 blennies infested on March 12. A3: 6 small (<12 cm) sturgeon infested on March 13. A4: 3 large (> 15 cm) sturgeon infested on March 13. The experiment was set at a water temperature of 16-17 °C, but due to a malfunction of equipment, the temperature increased to 21°C.
- High temperature. B1: 2 small sturgeon infested on March 14. B2: 4 small sturgeon infested on March 14. B3: 9 gambusia infested on March 14. B4: 6 blennies infested on March 13. Water temperature was maintained at 24 °C during the experiment.

On days 27-29 after glochidial inoculation, fish were isolated in aquaria without substratum and with a 5 mm mesh plastic net on the bottom to separate the fish from

TABLE 1

Fish from which the juveniles were obtained, container type and number of juveniles cultured in each tank. * Only three containers with juveniles obtained from blennies were suspended in this tank.

FISH	CONTAINER	TANKS			
		T1	T2	T3*	T4
Blenny	Plastic bottom	12	23	-	414
Blenny	Mesh bottom	144	33	112/54/393	267
Sturgeon	Plastic bottom	34	126	-	14
Sturgeon	Mesh bottom	308	394	-	152

excysted juveniles. Water was maintained at the same temperature as in the tanks, and no food was added. The bottom water layer was pumped through a 60 µm mesh every day until no more juveniles were found.

JUVENILE MUSSEL CULTURING

Recently released juveniles, recovered from each aquarium in the 60 µm mesh, were pipetted and put in plastic containers with 1 cm of clean fine substratum (particle size: 1–2 mm) from the Canal Imperial. All juveniles were counted but not tested for viability. Although all were used for experimentation, it is probable that not all were alive.

Two kinds of containers were used: one with a plastic bottom and the other with a 60 µm gauze mesh bottom. Juveniles collected from sturgeon were separated from those taken from blenny, and both were tested in the two containers. In this way, a total of 15 containers were suspended from foam platforms in four tanks (Table 1). The tanks were filled with well and green water, sediment from the Canal Imperial, soil, and vegetation from the Ebro River; and were continuously aerated (Fig. 1). In all tanks except T1, a pump was installed to flush tank water over the containers holding the juveniles. In T1, no pump was installed, but aeration of the water was greatly increased. Because we were testing the survival capability of juveniles in nutrient laden-water, we did not add any extra food to the tanks.

The experiment ran for 6 weeks, and all containers were regularly inspected for growth and survival of juveniles. The sediment of each container was screened through two sieves of 500 µm and 60 µm mesh. Juveniles were pippeted, counted, and when possible, measured (length, height and width). Dead juveniles were removed at each sampling, and the sediment was cleaned or changed. The inspection of each container took an average of 3 hours.

RESULTS

All glochidia used in the experiment were obtained from the mussels held in the aquarium with sediment. Release of mature glochidia occurred for 3 days only, between March 12 and 14. Mussels in the aquarium without sediment released only embryos and not mature glochidia.

Although all fish were successfully infested with glochidia, fish sloughed the glochidia in the 24°C tanks. Up to 8 days after infestation, glochidia were encapsulated on the gills of at least one of the 9 gambusia, but no glochidia were present by the day 15. Glochidia were observed on the blennies for the first few days, but none were

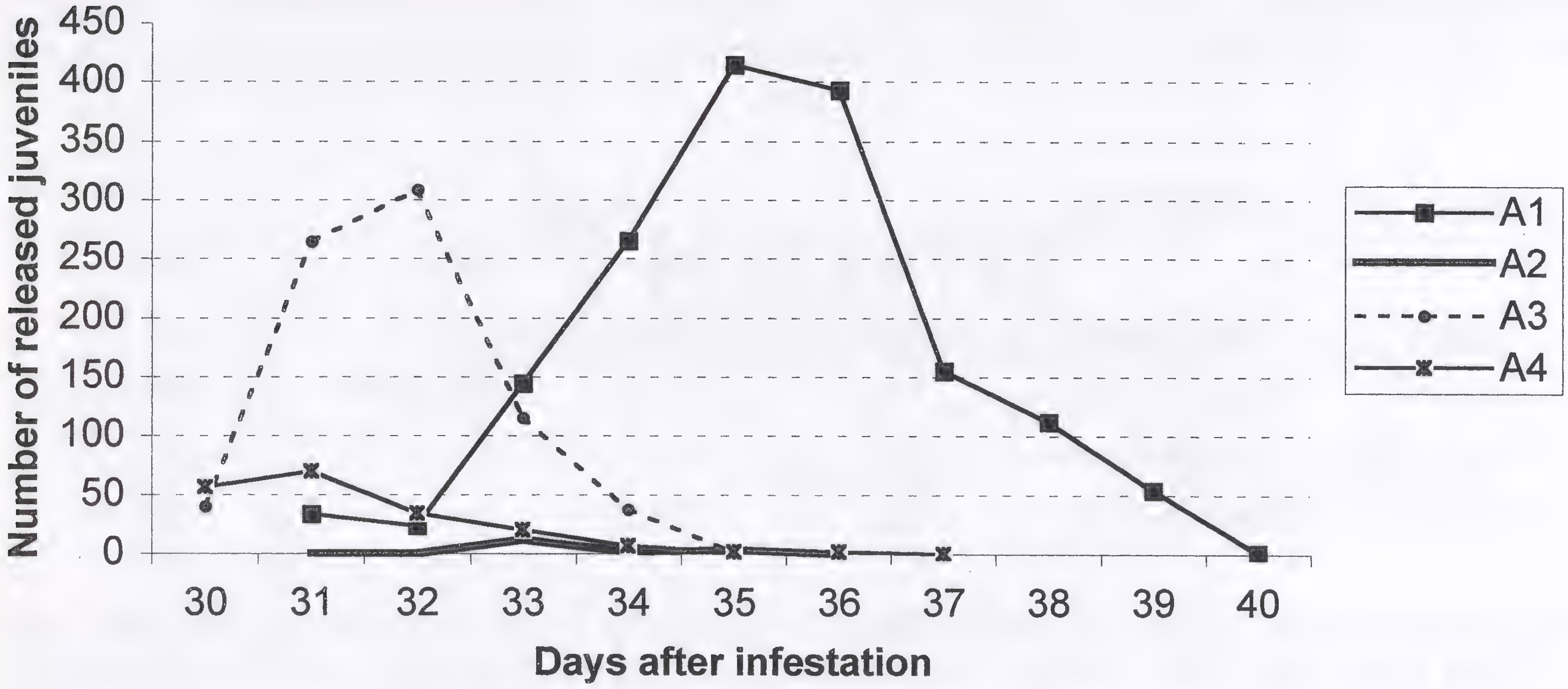

Figure 2 Release of 2,562 juveniles from the infestated fish. A1, A2= blenny. A3, A4= sturgeon. Temp = 21°C.

present 20 days after infestation. Sturgeon also maintained encysted glochidia for the first several days, but they were inspected less carefully for glochidia than the other fish species. For this reason, they were isolated 26 days after infestation in aquaria equipped with a net on the bottom, to collect any juveniles that transformed. No juveniles were found. Although unlikely, juveniles could have excysted in the tanks before the fish were isolated in aquaria.

Because the experiment at 24 °C was not successful, all the juveniles used for culture were taken from the infestation experiment at 21 °C. Only one fish in this experiment, a female blenny from tank A2, was not successfully infested with glochidia.

The release of juveniles began 30 days post-infestation for sturgeon and 31 days post-infestation for blennies (Fig. 2). Excystment occurred over 8 days for sturgeon and over 10 days for blennies.

The total number of juveniles used in the culture experiment was 2,562. Seven hundred seventy-six juveniles were excysted from the five small sturgeon, peaking on day 3 with 308 released juveniles. One hundred eighty-five juveniles were obtained from the three large sturgeon. Blennies produced more juveniles than did sturgeon. Five blennies in one aquarium released a total of 1,594 juveniles (peaking on day 5 with 414), but only 17 juveniles were released by the male blenny in the other aquarium (Fig. 2).

Although with varying degrees of success, juveniles were kept alive for at least 4 weeks in the four test tanks (Fig. 3). Juveniles survived up to 6 weeks in tanks T1 (4%) and T3 (11%) (Fig. 3). Survival was highest in the containers with gauze-meshed bottoms, although some juveniles remained alive until the fourth week in plastic-bottomed containers (Fig. 3D). In the most successful tank (T3), 13 living juveniles were found after 6 weeks (39 days) of culture. In the four tanks, mortality was greatest during the first 2 weeks. This may be due to the fact that not all juveniles were viable initially. We observed a substantial size increase in juveniles from both the sturgeon and blenny hosts (Fig. 4) (Table 2). Maximum dimensions for cultured juveniles were: length= 325 µm, width= 250 µm, height = 500 µm. The largest juvenile was measured in the sixth week of culture and was 350 µm height and 325 µm long (Figure 5). Although shell measurements were not taken of all juveniles, it appears that they grow more successfully in containers with gauze-mesh bottoms than in those with plastic bottoms.

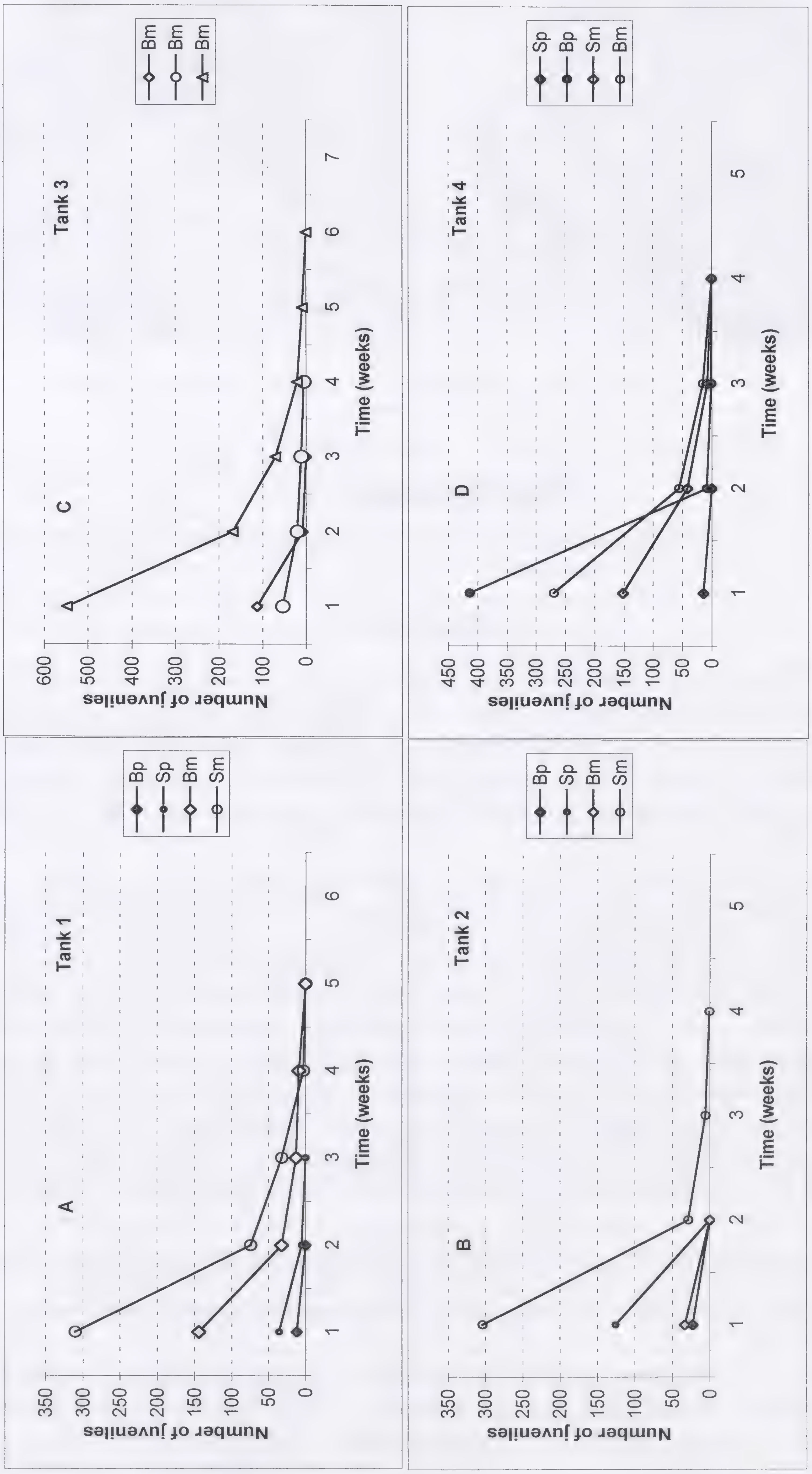

Figure 3 Survival of juveniles in containers in the four test tanks. B= blenny. S= sturgeon. m= meshed bottom container. p= plastic bottom container.

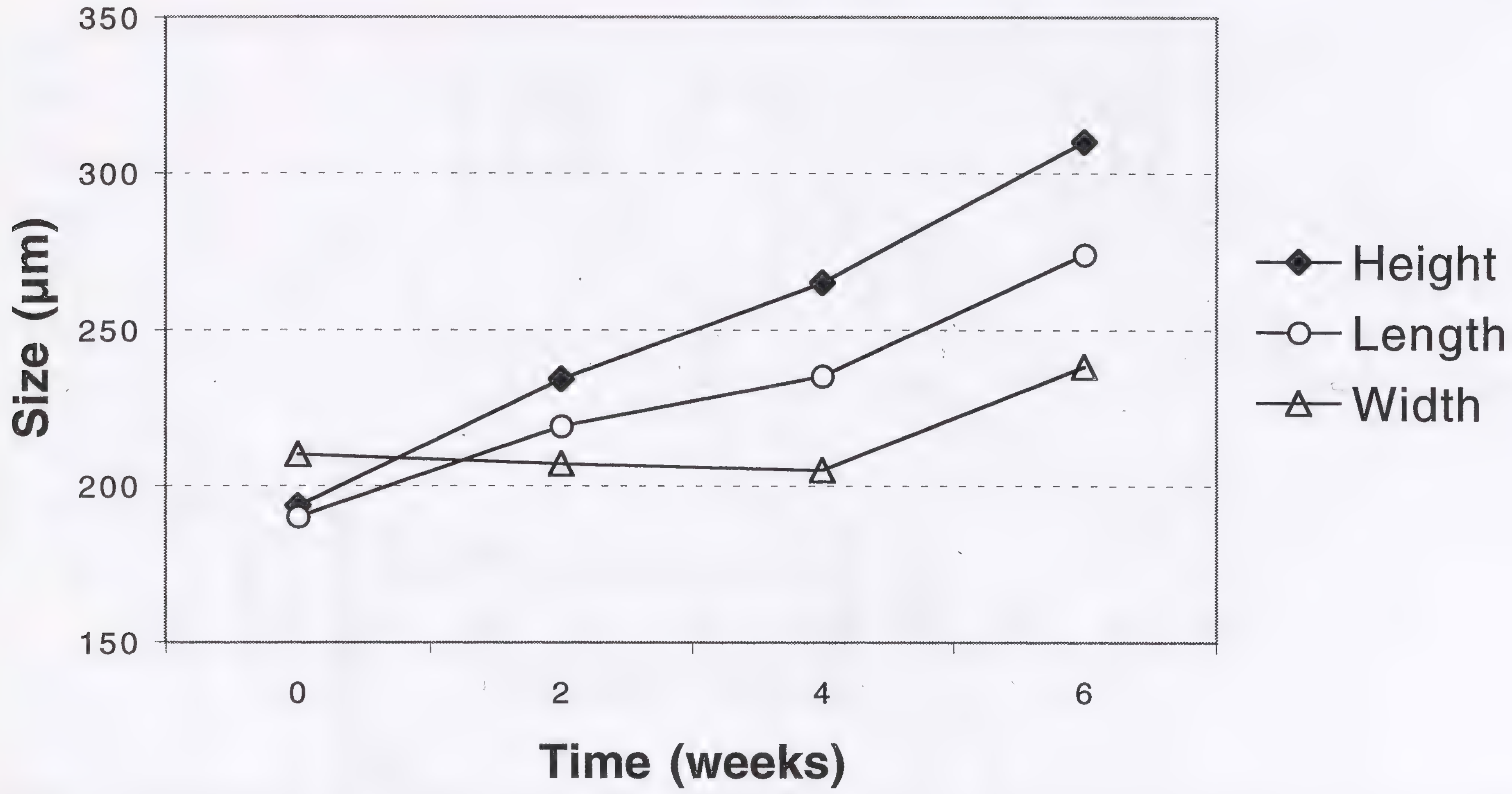

Figure 4 Mean juvenile shell size increase during culture. See Table 2 for details.

DISCUSSION

Results of these experiments show that captive propagation and juvenile culture of the critically endangered *Margaritifera auricularia* may be feasible in the very near future.

It is recommended to use gravid mussels and maintain them in the most natural conditions possible (i. e., water and sediment from the natural habitat). It is also advisable to harvest them quickly in order to obtain the required number of glochidia. Knowledge of the reproductive season of the species is critical, making the need for more basic research on the reproductive biology of the species imperative.

Results of the present study show that blenny, and the Adriatic sturgeon, can host the transformation of the glochidia of *M. auricularia*. As *A. naccarii* is the second species of sturgeon shown to support glochidial metamorphosis of this species (Araujo & Ramos, 2000b), it is likely that other species of *Acipenser* are suitable for captive breeding. Small sturgeon (approx. <12 cm) are highly recommended because they host more juveniles than large specimens and are more easily managed. Because our data on *gambusia* are not conclusive, experiments must be repeated with this species. Its distribution range does not overlap with that of *M. auricularia*, which is suspected of being stenotopic in terms of suitable glochidial hosts. Nevertheless, the period of time that elapsed between the infection and sloughing of the glochidia was longer in *gambusia* (8 days) than it was

TABLE 2
Standard deviation and mean juvenile shell size (µm) increase during culture.

WEEKS	0	2	4	6
LENGTH	190 n=1	219±19.93 n=15	235.45±27 n= 11	274.17±39.23 n= 18
HEIGHT	193.50±48.06 n= 4	234.06±32.18 n= 65	265.09±31.09 n= 54	309.62±69.45 n= 39
WIDTH	210±48.94 n= 4	207±18.01 n= 15	205±11.18 n= 5	238±17.68 n= 2

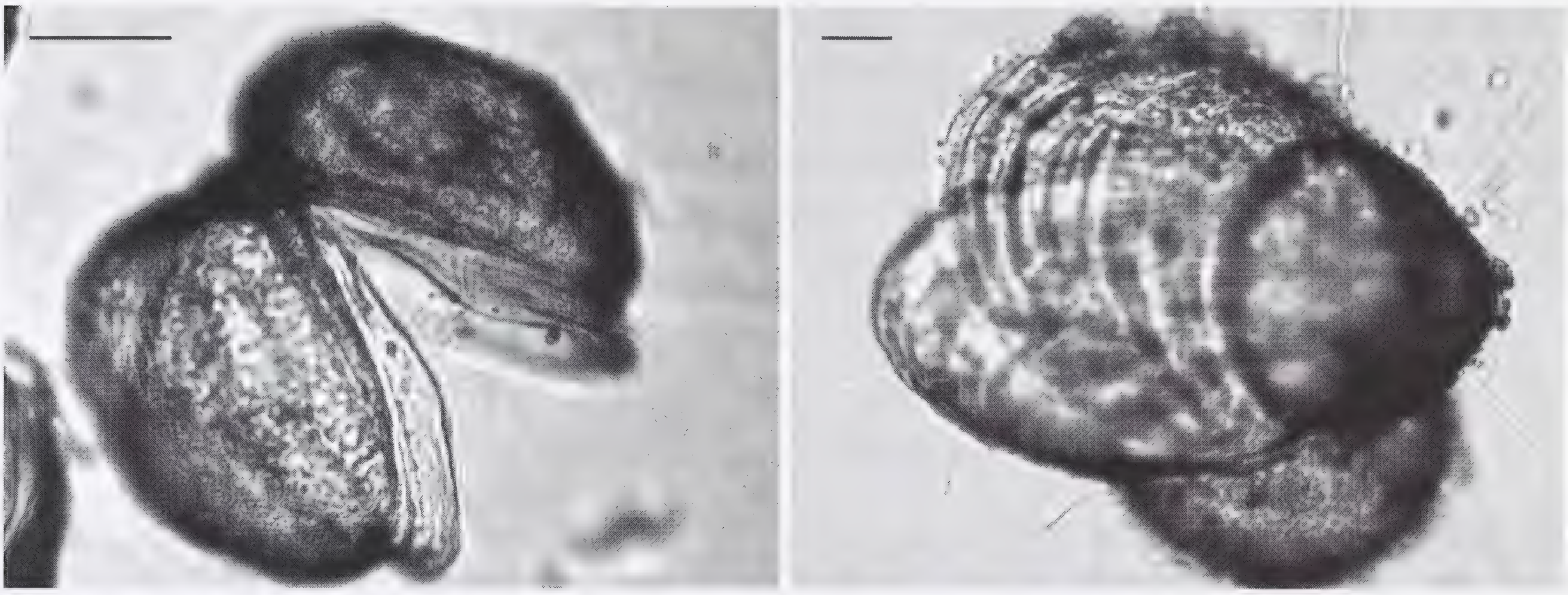

Figure 5 Juvenile shells of *M. auricularia* at release and at 6 weeks old. Scale bar: 40µm.

in other non-host fish that were tested (Araujo, Bragado & Ramos, 2001).

Water temperature is one of the main factors controlling the rate of metamorphosis of freshwater mussel glochidia in host fish. Araujo, Cámara & Ramos (2002) have demonstrated that the rate of metamorphosis of *M. auricularia* glochidia accelerates when water temperature is raised to 20°C, but does not accelerate at several degrees higher. Present data suggest that above 21°C this process is interrupted, although Araujo and Ramos (2000b) did observe the complete metamorphosis of *M. auricularia* glochidium in *Acipenser baeri* in 30 days at 23-24°C (ca. 700 degree-days). Thus, the possibility of an unobserved rapid metamorphosis in our experiment exists, but it is not very probable.

Although temperatures in the Ebro River never rose above 20°C in the months following the release of *M. auricularia* glochidia (March-April), conducting experiments at temperatures greater than 20°C could be of interest. Higher temperatures may accelerate juvenile growth and minimise production costs in future culture experiments of naiads.

Without redundant food and by maintaining "natural" conditions for culture, survival of some juveniles exceeded 1 month. Mean measurements of recently released *M. auricularia* juveniles are: length= 190 µm, width= 210 µm and height= 193 µm (Araujo, Cámara & Ramos, 2002). During six weeks of culturing, the (mean) dimensions of juveniles in our experiment increased by 51% in length, 60% in height and 23% in width, suggesting that at least some juveniles grow successfully during culturing.

Although we did not attempt similar experiments in containers without sediment, it seems that sediment is a very important factor for survival (Gatenby, Neves & Parker, 1996; O'Beirn, Neves & Steg, 1998). Survival is probably related to pedal-feeding behavior and juvenile stability. Our study suggests that some nourishment (probably detritus) was present in the culture containers, which increased suitability of the sediment. In our experiments, juveniles survived for 6 weeks, and pedal movements of the juveniles were observed, indicating that surviving juveniles were feeding. Due to their small size and fragility, it is improbable that recently released *M. auricularia* juveniles could survive without exogenous food as has been suggested for species of *Lampsilis* (Gatenby, Neves & Parker, 1996).

Oxygen may also play an important role in successful culturing. Our results showed that the system of circulating water over the cultured containers can be effectively replaced by simply increasing the oxygen levels in the tanks, thereby improving the oxygen flow through the containers.

Similar experiments using a nutrient-rich suspension generated directly from the river have been successful with the European margaritiferid *M. margaritifera* (Hruska, 1999). However, juveniles in these experiments were maintained for 5 years in semi-natural conditions in the river where the mussels previously survived.

Results appear promising for unionoid restocking using juveniles cultured in facilities that are connected to the species' natural habitat, or in facilities that duplicate the water conditions and food sources of these natural habitats. Nevertheless, further research on the relative importance of detritus, algae and bacteria in the freshwater mussel diet (adults and juveniles) is needed.

ACKNOWLEDGEMENTS

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RANGE EXTENSION OF THE 'WITHAM ORB MUSSEL' *SPHAERIUM SOLIDUM* (NORMAND)(BIVALVIA: SPHAERIIDAE) OR AN OVERLOOKED RESIDENT OF THE GREAT OUSE?

JON BASS[1], JOHN BLACKBURN[1] & CAROLINE GIRAUDY[1]

Abstract Sphaerium solidum *(Normand) is reported from the River Great Ouse, Cambridgeshire, adjacent to a RAMSAR site of high conservation interest. The previously known UK populations are confined to a single river system (River Witham, Lincolnshire). We speculate on the source of the newly discovered population.*

Key words Benthic sampling, Sphaerium solidum, *RDB status.*

INTRODUCTION

The present account describes the discovery of a population of *Sphaerium solidum* (Normand) in the Great Ouse at Earith in Cambridgeshire (National Grid Reference TL 394747). In Britain living examples of *S. solidum* were first found in 1968 and were confined to the River Witham and Timberland Delph (an associated deep fenland drainage channel) (Redshaw & Norris, 1974; Kerney, 1999). The Witham flows through Lincolnshire into the Wash at Boston, approximately 30km NW of the Great Ouse estuary at Kings Lynn.

Sphaerium solidum is widely distributed in central and S.E. Europe, but less common northwards through Germany and absent from Scandinavia (Kerney, 1999). In Britain, apart from the population of *S. solidum* in the River Witham system, Pleistocene fossil remains have been discovered but no Postglacial specimens are recorded (Kerney, 1999).

SAMPLING ACTIVITY

In 1999, the Environment Agency of England and Wales commissioned a study to compare the effectiveness of three sampling devices for collecting benthic freshwater invertebrates in rivers too deep for wading (Bass, *et al.*, 2001). Each sampler incorporated netting of similar mesh dimensions (*ca.*0.9-1mm apertures between meshes). Six relatively deep lowland river sites (Table 1) were visited to compare the performance of an extended (4m) long-handled pond-net, a Medium Naturalist's dredge (Holme, 1964) and the Mackey/Yorkshire pattern airlift sampler (Murray-Bligh *et al.*, 1997). Samples were taken in an upstream sequence to avoid disturbance effects. To maintain consistency with the current protocols used within the Environment Agency for dredge sampling from the river bank, the long-handled pond-net and the airlift sampler were used from a boat within dredge-throwing distance of the bank (5-8m). Six separate replicates were taken with each sampler from adjacent riverbed areas and each sample came from *ca.*1.5m^2 of riverbed.

River margin samples were also taken. One-minute pond-net sweeps were employed in the same manner as the standard three-minute collecting technique adopted by the

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1 Centre for Ecology and Hydrology (CEH Dorset), Winfrith Technology Centre, Winfrith Newburgh, Dorchester, Dorset, DT2 8ZD .

Environment Agency (England and Wales) and the Scottish Environment Protection Agency. This involved dividing the time of sampling activity in proportion to the coverage of available habitats within the margins of the reach sampled. The margin samples yielded lower volumes of debris and lower numbers of associated fauna than the deepwater samples, reflecting the relatively smaller areas that were sampled. Six one-minute margin samples were taken at each site, with three samples from each bank.

TABLE 1

Site locations where deepwater sampling methods were compared

Yorkshire Derwent at Stamford Bridge	NGR SE 710555
Yorkshire Ouse near Acaster Malbis	NGR SE 590453
Great Ouse/New Bedford River at Earith	NGR TL 394747
South Drove Drain near Spalding	NGR TF 219212
River Huntspill north of Bridgewater	NGR ST 303450
Severn at Upton-upon-Severn	NGR SO 851407

All samples were preserved on site with formaldehyde (4% final concentration). Macro-invertebrates were subsequently recovered from associated debris and most taxa were identified to family level. One of the six deepwater sites (Great Ouse, Earith) yielded sphaeriids clearly different from the usual range of species recorded from rivers and streams in the UK. Closer examination confirmed that *S. solidum* was present and the opportunity was taken to measure lengths of 'live' *S. solidum* shells and compare the number of individuals recovered by different deepwater sampling devices and the margin pond-net samples.

SITE LOCATION AND DESCRIPTION

The Great Ouse was re-routed in the 17th century when a straight artificial channel known as the New Bedford River (or Hundred Foot River) was constructed downstream from Earith. The watercourse then flows through Denver Sluice and discharges into the Wash at Kings Lynn. The river level at Earith (*ca.*50km from the sea) responds to tidal changes in the Wash because of the low-lying nature of the fenland landscape, but salinity changes do not extend inland as far as Earith.

The Environment Agency use this location at Earith as one of their routine monitoring sites. The river is around 25m wide with water depths range from 1.0–2.0 m and the predominant mean water velocity type recorded is 'slack' (<0.10 m sec^{-1}), under normal flow conditions. Direction of flow can change owing to the tidal conditions. The river channel is unshaded and an embankment is present on the right bank, looking downstream. Areas of seasonally flooded land – the Ouse Washes – are present on the left bank. These grazing meadows form an internationally important RAMSAR site for over-wintering wildfowl. Floodwater drains west from the grazing meadows through an extensive ditch system into the Old Bedford River, which runs parallel with the New Bedford River.

The riverbed at the Earith sampling site is predominately silt and clay, as recorded by the Environment Agency. At the time of sampling (21st July 1999) the river margin supported <10% cover of submerged aquatic plants (dominated by *Potamogeton* spp) and the river banks had around 50% cover of emergent plants (dominated by *Glyceria maxima* L.). These habitat data are of general interest because a 3-minute pondnet sample (targeting habitats in proportion to their cover area) is used throughout the UK as the standard macro-invertebrate monitoring approach when assessing running water site quality.

RESULTS

Comparisons of macro-invertebrate taxa captured by the different sampling devices revealed that, on the Great Ouse at Earith, the most striking features are: (1) a relative paucity of molluscan families in the river margin when compared with mid-river deep-water habitats (a reversal of the position noted in the wider dataset); (2) the complete absence of *S. solidum* from pond-net samples at the river margin (Table 2); and (3) the low occurrence of other sphaeriids of similar size in these margin samples (Table 3). Voucher specimens of *S. solidum* have been forwarded to the Non-Marine Recorder of the Conchological Society of Great Britain and Ireland.

TABLE 2

Shell length frequency of *Sphaerium solidum* (Normand) collected from the Great Ouse at Earith (July 1999), showing a comparison between sampling devices. Numbers in each shell size category are derived from the combination of six sample replicates for each sampling device.

No. of individuals in each size category

Yorkshire Airlift	4	1	8	4	4	1		2				1				1	2
Medium Naturalists Dredge	1	3	1	1	1			1									
Long-handled Pond-net	1	1	3	3	1	1									1		2
Standard Pond-net (margin)																	
shell length (mm)	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**

TABLE 3

Numbers of Sphaeriidae of comparable size range collected from the Great Ouse at Earith (July 1999): comparison between sampling devices (each data set is derived from six samples, as in Table 2).

Species	**Airlift**	**Dredge**	**Long-handled Pond-net**	**Standard Pond-net (margin)**
S. solidum (Normand)	28	8	13	0
S. corneum (L.)	40	21	40	2
P. amnicum (Muller)	11	16	5	1

DISCUSSION

Sphaerium solidum is classified as "Endangered" in the UK, based on Red Data Book categories (Bratton, 1991). In terms of its UK status, the discovery of a population in a second UK river system reduces its potential vulnerability to a localised pollution event but is probably not sufficient justification for a reappraisal of its conservation status. Interestingly, there were unsuccessful searches for *S. solidum* conducted in Timberland Delph and the main River Witham during June 2001 and early in 2002, respectively, at previously known sites for the species. Just 2 old shells were found, compared to the recovery of at least 20 live individuals plus many dead shells during a field visit by the Conchological Society, some ten years previously (Ian Killeen, pers. Comm.).

Sphaeriidae are rarely identified to species during routine freshwater invertebrate monitoring and therefore *S. solidum* may occur in other similar river systems. Another potential reason for under-recording is the convenience of bank-side sampling. Readily accessible bank-side habitats may differ markedly in character from the habitats present in mid-river. In the broader study based on six sites (Bass *et al.*, 2001) we compared macro-invertebrate families represented in 'mid-river' and 'margin' samples to gauge the potential for under-recording taxa that are largely restricted to deepwater habitats. Interestingly, no molluscan families were captured exclusively in the deep-water samples, whilst the margin pond-net samples yielded additional records of Unionidae (four sites) Dreissenidae and Valvatidae (each at one site), despite the smaller volumes of material collected in margin samples. In contrast, at Earith, one species, *S. solidum*, was recovered exclusively from the deep-water samples and sphaeriids of similar size (*Sphaerium corneum* and *Pisidium amnicum*) were also poorly represented in river margin samples.

The extent, origin and long-term stability of the population of *S. solidum* in the lower River Great Ouse are uncertain and intriguing. If the population is native to the site, why has it been overlooked when adjacent to a well-studied RAMSAR site? Although the Great Ouse Earith site has been monitored by the Environment Agency (and previous regulatory organisations) over many years, margin pond-net sampling has been the preferred sampling method. Macro-invertebrate identification to family level, precludes a realistic assessment of the long-term status of *S. solidum* at this site. Some sphaeriid species records were obtained for the Great Ouse in the late 1980s (Bass, unpublished data). They relate to five sites between Needingworth and St Neots (10-30km upstream of Earith) and included margin pond-net samples and more limited mid-river grab samples. *Sphaerium solidum* was not represented, whilst 10 other species of Sphaeriidae were identified from *ca.*200 specimens.

It is noteworthy that a tidal barrier is present on the Great Ouse at Brownshill Staunch between Earith (the present sample site) and Needingworth and therefore upstream colonisation by *S. solidum* from the lower reaches may be constrained. Flood events on the River Witham, capable of displacing small bivalves into the Wash, could result in successful colonisation events by *S. solidum* in the lower reaches of adjacent river systems. However, we consider this scenario unlikely, as periods of reduced salinity in the Wash are localised and of limited duration because seawater and river water mix during the tidal cycle. The movement of small fishing boats between the river estuaries of the Wash may transfer sediment-associated fauna, but this is also thought to be unlikely as each boat tends to operate from a single port. A more extensive survey would establish whether connected and adjacent watercourses support populations of *S. solidum.* The fenland drains and lower reaches of the rivers Welland and Nene provide similar habitat conditions between the catchments of the rivers Witham and Great Ouse.

We are not aware of recently published sphaeriid records from the lower reaches of the Great Ouse/Cam drainage system, aside from the study that established the presence of eight sphaeriid species, including the infrequently found *Pisidium pseudosphaerium* Schlesch, in waterbodies at Wicken Fen (Painter, 1999).

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THE CRYPTIC OCCURRENCE OF *STAGNICOLA FUSCUS* (GASTROPODA: LYMNAEIDAE) IN THE BRITISH ISLES

RON CARR[1] & IAN J. KILLEEN[2]

Abstract *Anatomical evidence is presented to confirm that the taxon formerly regarded as* Lymnaea palustris *(Müller, 1774) includes a second British species,* L. (Stagnicola) fuscus *(C. Pfeiffer, 1821). The two species are assigned to the genus* Stagnicola, *(Jeffreys, 1830), as currently accepted by modern continental authorities.*

Key words Lymnaea palustris, L. (Stagnicola) fuscus, *British species.*

INTRODUCTION

The familiar aquatic snail *Lymnaea palustris* (Müller, 1774) has hitherto been considered by British authors to represent only a single species with a wide distribution in the British Isles (Kerney, 1999). Revised treatment of the taxon by continental malacologists over the past forty years has been referred to by Kerney (1999) and amplified by Killeen (1999), though largely ignored by British workers.

This tendency has largely been due to the extent that conchological criteria have historically dictated taxonomic issues. Recent molecular studies (Bargues and Mas-Coma, 1997; Bargues *et al*, 2001) have broadly concluded that generic differentiation of the Lymnaeidae shall be as follows: *Radix* (*peregra* group of species); *Lymnaea* (*stagnalis* and European Stagnicolines with *Stagnicola* as a subgenus of *Lymnaea*); *Omphiscola* (*glabra*) and *Galba* (*truncatula*). The fusion of *Stagnicola* in synonymy with *Lymnaea* sensu stricto has not yet been adopted on a wider level but seems likely to be so.

TAXONOMY AND DISTRIBUTION

Jackiewicz (1959, 1988,) long ago recognised a complex of anatomically well defined but conchologically indistinct species within the taxon *Galba palustris* O.F. Müller, 1774 which have been assigned by subsequent continental authorities to the genus *Stagnicola* Jeffreys, 1830 (Falkner, 1995, Glöer and Meier-Brook, 1998).

Stagnicola turricula (Held, 1836) and *S. occultus* (Jackiewicz, 1959) are known to have restricted distributions in central Europe (Glöer and Meier-Brook, 1998), though *S. corvus* (Gmelin, 1791) was described from the Netherlands by Van der Velde and Kassel in 1984. *S. fuscus* (C. Pfeiffer, 1821) has been reported by Falkner (1995) to extend from central Europe as far west as France and Ireland and would appear to be the most widespread species. Information concerning the distribution of *S. fuscus* in France is provided by Falkner *et al* (2002), who conclude that it is commoner of the two species in that country.

In Germany, the true *S. palustris* is confined principally to the north of the country, with *S. fuscus* being commoner in the south and *S. corvus* having a somewhat disjunct distribution throughout the country as a whole (Glöer and Meier-Brook, 1998).

The reproductive anatomy of *C. fuscus* was described by Jackiewicz (1988) under the name *Lymnaea vulnerata* (Kuster, 1862). A subsequent taxonomic revision of the species was presented by Falkner (1995).

1 9 The Mallows Maidstone Kent ME14 2PX
2 163 High Road West, Felixstowe, Suffolk IP11 9BD

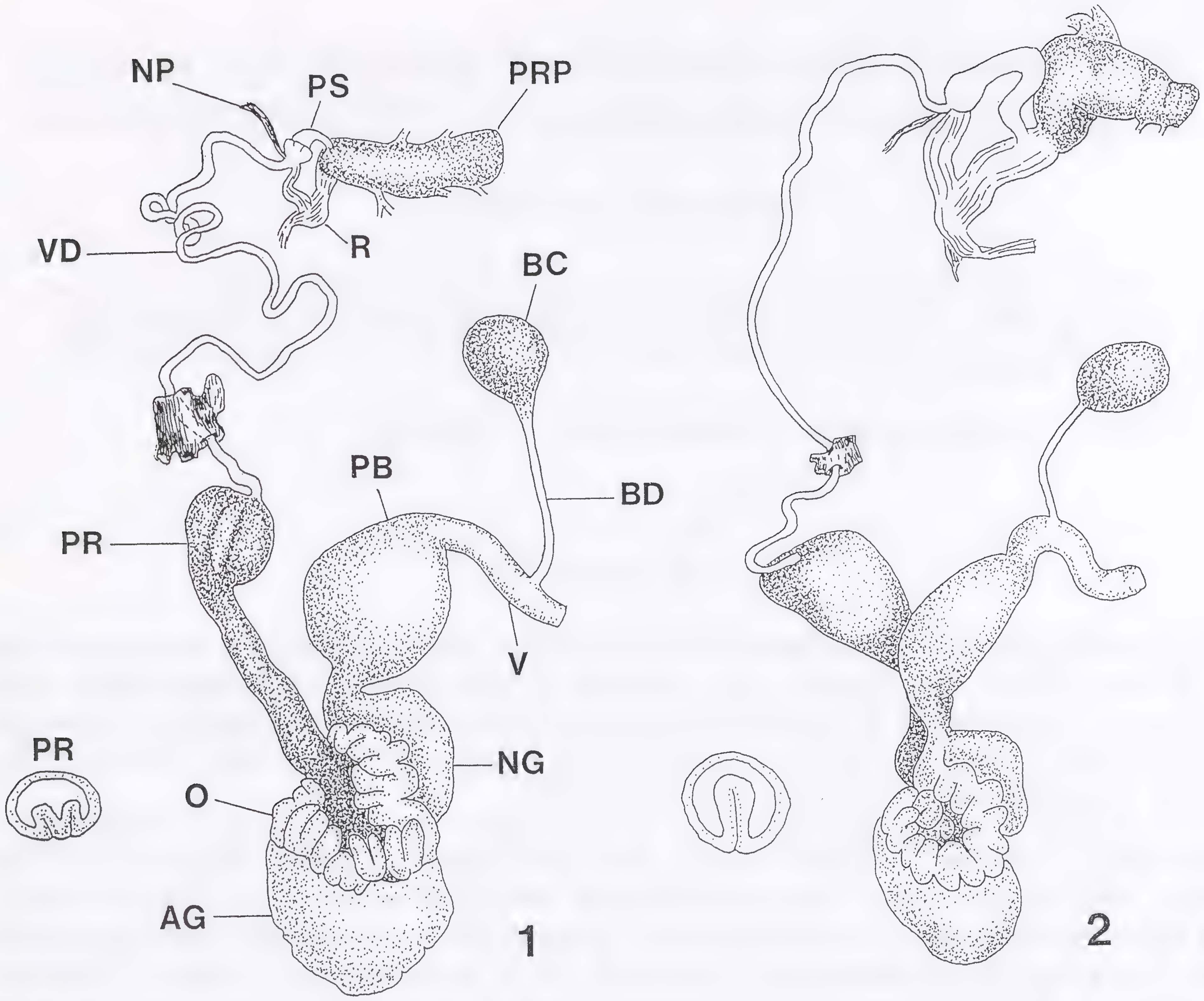

Fig. 1 **1** *Stagnicola fuscus* (C. Pfeiffer, 1821). Dymchurch, (Romney Marsh), Kent. AG = Albumen gland BC = Bursa copulatrix BD = Bursal duct NG = Nidamental gland NP = Nerve of penis O = Oviduct PB = Pyriform body PR = Prostate PRP = Praeputium PS = Penis sheath R = Retractor muscle V = Vagina VD = Vas deferens **2** *Stagnicola palustris* (Müller, 1774) Weavers Way Drain, near Potter Heigham, Norfolk. Scale bar = 1mm.

MATERIAL EXAMINED

Sexually mature specimens collected from twenty four locations in Britain have been preserved in 70% alcohol and dissected. The true *S. palustris* has so far been found to occur from only five locations in County Durham, Norfolk, Surrey East Sussex, and Fife. Specimens from all the remaining localities have been identified as *S. fuscus*.

Anatomical distinctions within the reproductive system are immediately apparent between the two species, particularly with regard to the penis sheath, which is much longer in *S. palustris* (Fig. 1). Jackiewicz quotes the ratio of the praeputium to the penis sheath in *S. palustris* as 1:1⅓ and in *S. fuscus* as 1:⅓. In the examined British material, the length of the penis sheath was found to vary in the latter species, sometimes being as short as ¼ the length of the praeputium.

The bulbous termination of the penis sheath was occasionally found to exhibit a distinct annulus, corroborating the observations of Jackiewicz (1988). The pyriform body was observed to be roughly spherical in *S. fuscus* but oval by comparison in *S. palustris*. In *S. fuscus* the prostate gland was found to be less swollen at its terminal end than in *S. palustris*.

The transverse section of the prostate is diagnostic between different members of

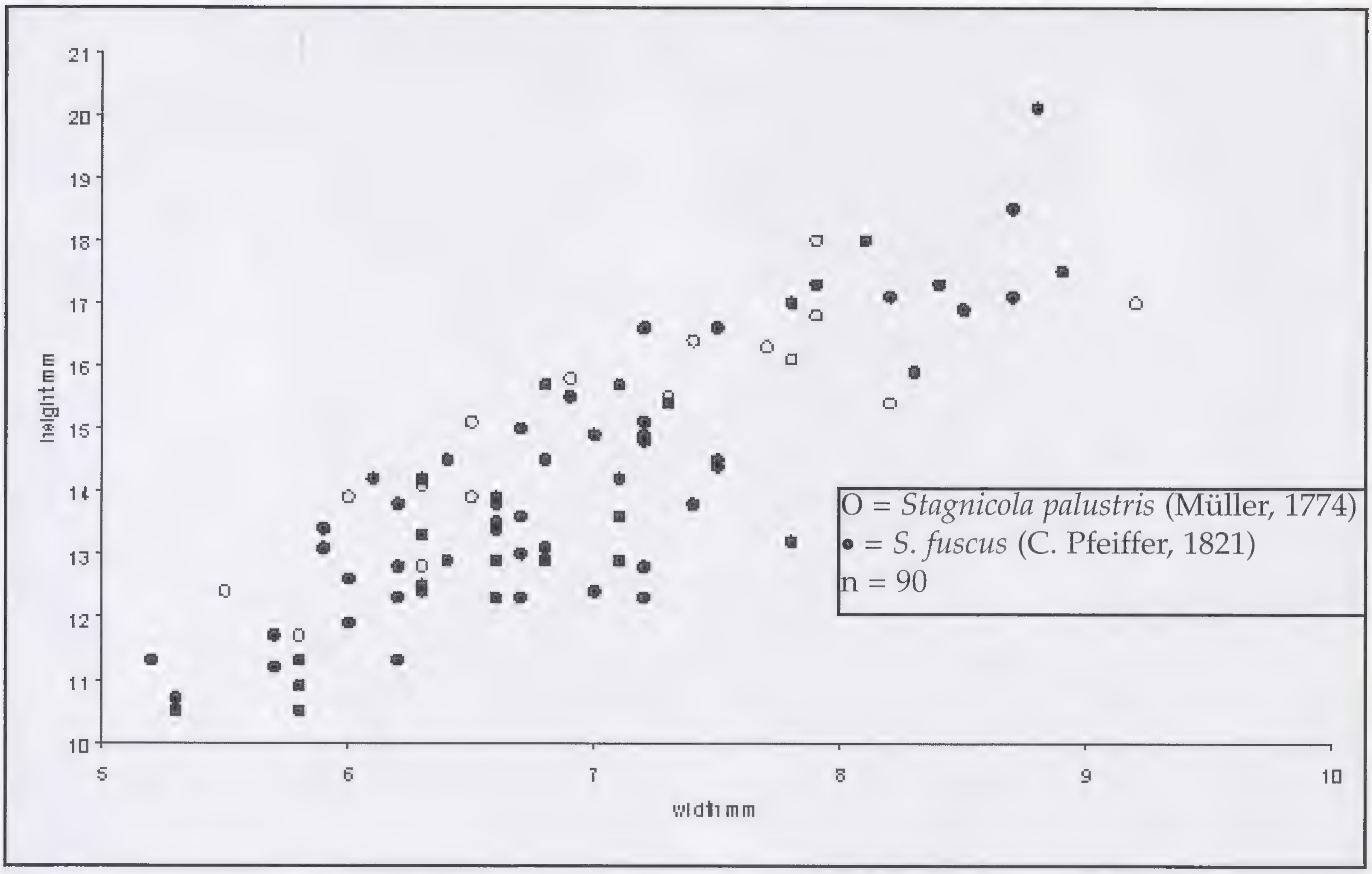

Fig. 2 Width plotted against height of *Stagnicola palustris* and *S. fuscus*

the genus. Two folds are present within the internal lumen of the prostate in *S. fuscus* whereas only one, longer fold is present in that of *S. palustris* (Fig. 1). It is possible that a third species, *S. corvus* may occur in the British Isles. This species exhibits a praeputium to penis sheath ratio similar to that of *S. fuscus* but may be distinguished by many smaller and larger folds present within the internal lumen of the prostate (Jackiewicz, 1959, 1988).

Collection sites *S. palustris* - County Durham: Joe's Pond (NZ 3248). East Sussex: Hooe Level (TQ 671056). Norfolk: Weavers' Way Drain (TG 434194). Surrey: Wimbledon Common (TQ 235729), Fife: Cupar (NO 352164). *S. fuscus* - West Kent: East Peckham (TQ 680493). Beltring (TQ 678478), East Kent: Chislet Marshes (TR 229675), Romney Marsh (TR 091291), Stanford (TR 134385). East Sussex: Hooe Level (TQ 671056), Manxey Level (TQ 651068), Manxey Level (TQ 669075), Rodmell (TQ 422066), Woodingdean (TQ 359074). Surrey: Effingham (TQ 110558) Hampshire: Crockford Bridge (SZ 350989), Cambridgeshire: Woodwalton Fen (TL 2385). Cumbria: Loughrigg Tarn (NY 3404). Suffolk: Carlton Marshes (TM 506992). Gwynedd: Rhyd-y-Clafdy (SH 3335). Dumfries and Galloway: Perchhall Lock Moss (NY 109878). Fife: Newburgh (NO 203134), Auchtermuchty (NO 272113), Pitmedden Forest (NO 193137). Additional specimens of *S. fuscus* have been examined from nine sites in Northern Ireland.

Measurements *S. palustris*- range: height 12.4–18.0mm, width 5.5–9.2mm. Mean: height 15.8mm, width 7.6mm (n = 13). *S. fuscus* - range: height 8.8–26.1mm, width 4.3–11mm Mean: height 13.9mm, width 6.7mm (n = 77).

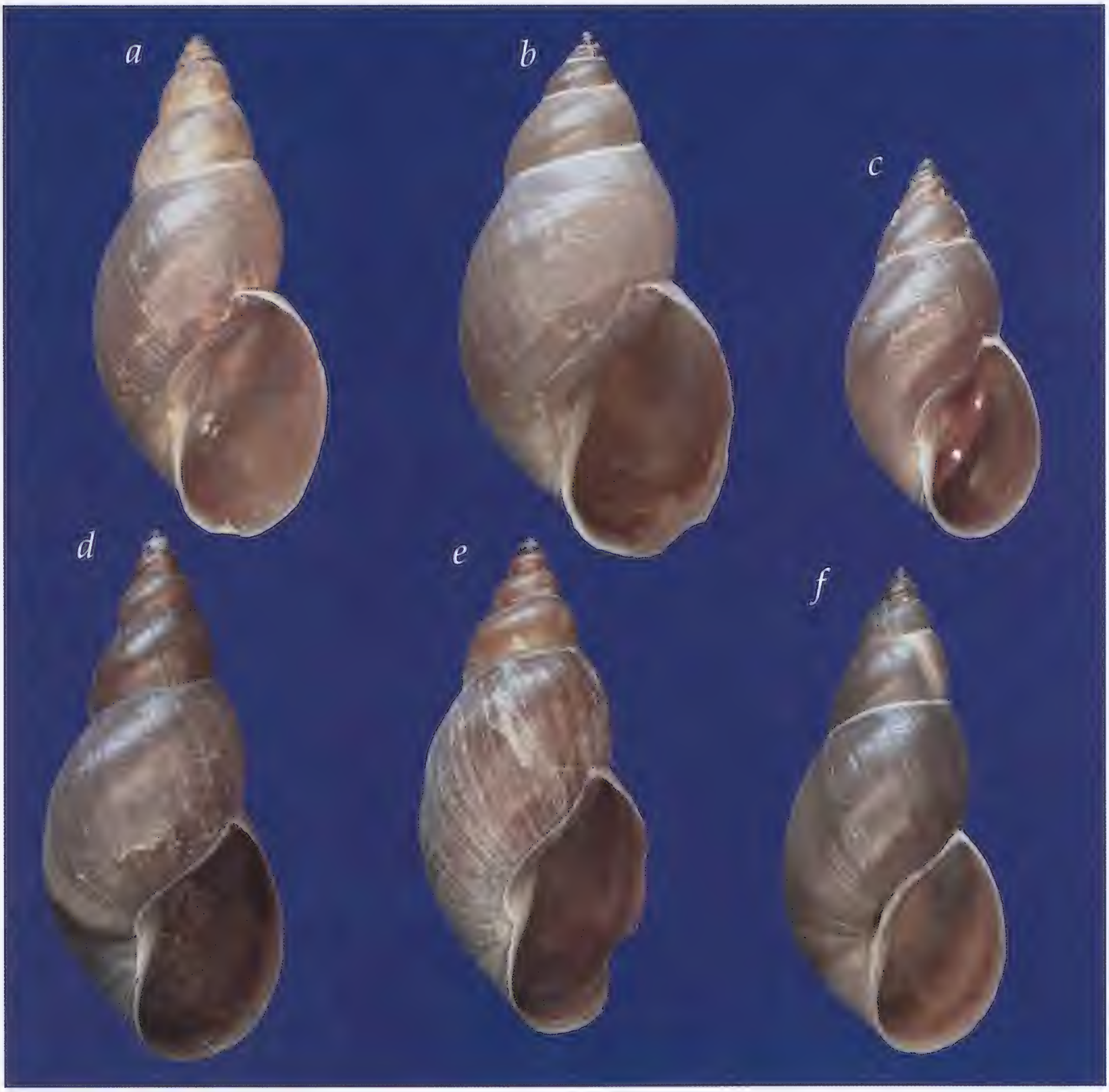

Fig. 3 **a–c** *Stagnicola fuscus* (C.Pfeiffer, 1821), Dymchurch **d–f** *Stagnicola palustris* (Müller, 1774). Weavers Way Drain

Discussion

A scatter plot (Fig 2) demonstrates that due to variation of shell size and morphology in both species, conchological differentiation is extremely unreliable. The greatest variation in size is displayed by *S. fuscus,* a specimen from Carlton Marshes, Suffolk, attaining dimensions of 26.1mm height, 11mm width, though obviously more shells of this species have been available for measurement. Examples of shell specimens are provided in Figure 3.

Both *S. palustris* and *S. fuscus* are characteristic of well-vegetated, shallow water bodies that are prone to summer desiccation. The sympatric occurrence of the two species in such a habitat has been observed at Hooe Level, East Sussex, where one specimen of *S.palustris* was collected with six specimens of *S. fuscus.*

Pending the examination of material from a wider range of localities, precise distributional data is as yet unavailable. *S. palustris* would certainly appear to be the less common of the two species in the southeast of the country. Both species have been recorded as far north as Fife. The distribution map presented by Kerney (1999) must now be regarded as an aggregation of two anatomically distinct species.

ACKNOWLEDGEMENTS

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A COLONY OF PALE-LIPPED *CEPAEA NEMORALIS*

L. M. COOK[1]

Abstract *A colony of* Cepaea nemoralis *polymorphic for banding and white or dilute pigmented lip has been re-surveyed after 44 years. Frequencies of banding and lip colour are unchanged, although mid-banded has declined in frequency. Aberrant frequencies of banding in intermediate years, when the snails were rare, suggest that density-dependent visibility bias may occur. The peculiar association of lip colour and banding indicates that the colony was founded by unusual mutant individuals. Lip colour variation and frequency suggests that the allele concerned may show great breadth of expressivity.*

Key words Cepaea, *polymorphism, morph frequency change, genetic expressivity*

INTRODUCTION

Stratton (1958) recorded a colony of *Cepaea nemoralis* at Malham, North Yorkshire which contained white-lipped individuals. Further details have been given for the early 1960s (Cook, 1966). The normal colour of the peristome, or lip, of the shell in this species is dark brown, as distinct from *C. hortensis*, in which it is white. Lip colour is affected by an allele, albolabiate, at the P locus, which also has alleles that reduce pigmentation in both bands and lip (Murray, 1975). Cain *et al.* (1968) examined sample data which suggested that this allele is not completely recessive, but results in partial pigmentation in heterozygotes. In addition, there may be another locus which influences lip colour (Murray, 1963). White lip occurs as a common polymorphism in some parts of the range (especially the Pyrenees and western Ireland), but elsewhere it is rare. Stratton's colony appears to be completely isolated and presumably the result of chance retention of a mutation. The population genetics of *Cepaea* continues to yield interesting problems (e.g. Bellido *et al.*, 2002), so that it is worth reporting on the further progress of the Malham colony.

SAMPLING DATA

A general survey of the Malham area showed that *C. nemoralis* colonies occur on limestone outcrops, or scars, isolated from each other by more acid grassland (Stratton, 1956). The 15 colonies examined were uniformly yellow in ground colour, except for a single colony in which pink shells occurred, but polymorphic for banding. Only one colony contained white lipped shells, at a site called Green Hill Scar by Stratton (Great Hill Scar on current 1/25000 maps). The site consists of a length of limestone outcrop a few m high and about 40 m in width with scree below it. There is some level limestone above and sloping grazed sward below. Stratton (1958) gives further details of banding pattern and degree of lip pigmentation, but dividing his sample into three main categories, the numbers he obtained are shown in the first row of Table 1. Two further samples by Cook (1966) were made at times when the animals were rare (rows 2 & 3, Table 1). The site was resampled in 2002 when the snails were extremely abundant (row 4, Table 1). The samples from the 1960s were scored and returned to the site. In the latest sampling 188 individuals were kept for further scoring while the rest were returned. The banded allele is completely recessive to unbanded and albolabiate is at least partially recessive to full colour, so that the banded, unpigmented lip class are expected to be double homo-

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[1] The Manchester Museum, University of Manchester, Manchester M13 9PL U.K. email:lcook@man.ac.uk

TABLE 1
Samples collected at successive dates. Row 1 from Stratton (1958), rows 2 and 3 from Cook (1966), row 4, this paper.

year	unbanded pigmented lip		unbanded unpigmented lip		banded unpigmented lip	
	n	%	n	%	n	%
1958	41	33.6	14	11.5	67	54.9
1961	31	49.2	18	28.6	14	22.2
1963	11	55.0	5	25.0	4	20.0
2002	126	19.7	62	10.1	315	70.2

zygotes. The P locus is linked to banding. Owing to the slow reproductive rate, linkage distances have not been established accurately. Some data of A.W. Stelfox suggest up to 10 per cent recombination (Cook, 1967). Wild colonies often show extreme linkage disequilibrium between lip colour and ground colour or banding loci, however, just as they do between the closely linked colour and banding loci themselves.

All banded individuals from this colony are albolabiate, that is, the lip of the shell is either completely white or else there is a very small amount of pale pink/brown pigmentation. In the 2002 sample 81 of 132, or 61 per cent, showed some signs of pigmentation, the rest having the peristome white. Stratton (1958) refers to these simply as white-lipped, but it is evident that even when homozygous the albolabiate allele does not always inhibit pigment production entirely.

Unbanded shells are divided into two categories. Unbanded white-lipped individuals have a lip with no pigment or no more than is found in any of the bandeds. Banded pigmented-lipped individuals either have the lip as intensely coloured as is usual in the species or else with some degree of dilution. The two unbanded classes are easily separated, there being discontinuity between the pigmented and unpigmented groups.

ANALYSIS

OBSERVED FREQUENCY CHANGE

The first striking feature of these data is the change in frequency of banding with time. The samples are heterogeneous (x^2 = 50.84, 6 d.f., P < 0.0001). Results from the two central collections are homogeneous, however, (x^2 = 0.21, 2 d.f., P=0.9). They differ significantly from the first and the fourth collection, which do not differ from each other (x^2 = 3.70, 2 d.f., P = 0.15). Either the frequency changed radically between 1958 and 1962, then returned to the original frequency over a subsequent elapse of about 15 generations or there is something unusual about samples 2 and 3.

One possible explanation for the difference is that the intermediate samples were made in a part of the site which differed in frequency from the rest. This is unlikely, however, as the colony area is small and at the present time appears uniform. Experience while collecting suggests instead that the result may reflect sampling bias. Unbandeds were more conspicuous at a distance than bandeds. Samples near the true frequency are likely to be collected when snails are abundant, because neighbouring individuals are picked up whenever a shell is first seen in an area. When they are rare, however, the snails tend to be distributed as isolated individuals, and individual bandeds may have a greater chance of being overlooked than unbandeds.

TABLE 2
Morph frequencies based on 1958 and 2002 data assuming no change in frequency. For the 3-chromosome model discussed in the text, chromosome frequencies are estimated as $p = 1-q-r$, $q = \sqrt{(c+d)}-\sqrt{d}$, $r = \sqrt{d}$.

	unbanded	banded
pigmented lip	a = 0.2672	b = 0.0
unpigmented lip	c = 0.1216	d = 0.6112

If this is the explanation for the difference, the bias is surprisingly great. Assuming the morph frequency to have been unchanged from the 45 per cent unbanded, 55 per cent banded of 1958, the 78:22 ratio in 1961-63 suggests that individual unbandeds were four times more likely to be found than bandeds. A bias of that magnitude has implications, not only when recording morph frequency in colonies, but also with respect to selection by predators. The effect of selective predation on morph frequency depends on both relative visibility and predation rate. If there is no predation then differential visibility is irrelevant. If predation is substantial, however, selection will have a correspondingly important effect on future morph frequency. This result suggests that relative visibility may be appreciably density dependent in its effect, so that predation will modify morph frequency when numbers are low but not when they are high.

Another morph present in the colony is mid-banded, modifying the appearance of banded individuals and unlinked to the other loci discussed. There were 29.9 per cent in 67 banded individuals in 1958, which had dropped significantly to 17.5 per cent in 315 by 2002 ($x^2 = 5.38$, 1 d.f., $P<0.05$), so that the frequency of the mid-banded allele may be falling.

MORPH AND ALLELE FREQUENCIES

Assuming that the first and last samples represent good estimates of an unchanging morph frequency with regard to banding and lip, the mean frequencies of the three phenotypes are those shown in Table 2 (the conclusions will be the same whether these figures are pooled or analysed separately). The curious feature of the data is the absence of the banded, pigmented-lipped class. In the light of this it is of interest to examine what the frequencies can tell us about the expression of the albolabiate allele. Given the morph frequencies the initial assumption would be that three chromosome types are present in the population: unbanded, pigmented-lipped, unbanded unpigmented-lipped and banded, unpigmented-lipped (the three chromosome model). Alternatively, if a further assumption is made, there might be only unbanded, pigmented-lipped and banded, unpigmented-lipped chromosomes, the unbanded unpigmented-lipped class being heterozygotes (two chromosome model).

(i) Three chromosome model. Assume that albolabiate can never be dominant. Then the data in Table 2 show the estimated frequencies of unbanded, pigmented-lipped, unbanded, unpigmented-lipped and banded, unpigmented-lipped chromosomes to be $p = 0.1440$, $q = 0.0742$ and $r = 0.7818$. The unbanded, pigmented-lipped class comprises p^2 homozygous and $2p(q+r)$ heterozygous for lip colour, or 0.0207 and 0.2465. Consequently, 92.3 per cent of unbanded, pigmented-lipped individuals should be heterozygous.

Many shells in this class do in fact show dilute pigmentation, so that either genetic background in this colony sometimes results in dilution or the albolabiate allele is sometimes, but not always, incompletely recessive. In Stratton's sample 32 of 41, or 78 per cent, had dilute pigmentation. In the one retained for examination in 2002 the fraction was 14 in 37, or 38 per cent.

We might also conclude that banded shells with traces of pigment were heterozygous for banded, pigmented lip, but in that case a substantial fraction of banded individuals should be fully pigmented homozygotes. In the scored 2002 sample 61 per cent of the banded individuals had traces of pigmentation, which suggests a full pigment allele frequency of 0.305. There should therefore be some 30 banded, pigmented-lipped individuals in the complete 2002 sample. What is certain is that none was found in any of the four samples.

A feature of the 3-chromosome model is that it assumes one or other of two unlikely events. The first is that there were two mutations. One such scenario is that mutation from pigmented to unpigmented lip occurred twice, once on the lone banded chromosome present in the foundation stock of the colony, and again on an unbanded chromosome. (If there were more than one banded unpigmented chromosome among the founders, but no banded pigmented chromosomes, then the problem is put back to the unknown colony from which these founders came). Another would be that the colony began entirely with unbanded, pigmented-lipped individuals. One of these mutated to albolabiate and subsequently a chromosome in the albolabiate lineage mutated to banded.

Alternatively, the colony started with unbanded, pigmented-lipped individuals and the mutant banded, unpigmented-lipped chromosome. Subsequently there was a crossover event which gave rise to the unbanded, unpigmented-lipped recombinant type but not the reciprocal banded, pigmented-lipped one.

It is evident that the albolabiate allele has variable expression; it may be completely or incompletely recessive in heterozygotes. If we assume that it may sometimes be completely or nearly completely dominant then it is possible to consider a more economical model in which the colony was founded by individuals with unbanded, pigmented-lipped individuals plus a single banded chromosome on which lip colour had mutated to albolabiate.

(ii) Two chromosome model. If there are only two chromosome types the unbanded, unpigmented-lipped class consists of heterozygotes in which white lip is fully expressed. If these were the only heterozygotes then by simple allele counting the allele frequencies would be estimated as $p = 0.3280$ for the unbanded, pigmented-lipped chromosomes and $q = 0.6720$ for banded, unpigmented-lipped chromosomes. Consequently the expected frequency of unbanded, unpigmented-lipped individuals on the basis of random assortment would be 44.1 per cent, compared with an observed frequency of 12.2 per cent. The deviation is highly significant ($x^2 = 245.4$, 2 d.f.); there are too few heterozygotes, so that some of the unbanded pigmented-lipped category must be heterozygous.

The best available estimate of banded, unpigmented-lipped chromosome frequency then becomes $\sqrt{0.6112}$, or 0.7818. The alternative unbanded, pigmented-lipped chromosome type has a frequency of 0.2182. Consequently, among the 0.2672 of the population which are scored as unbanded, pigmented lipped, 0.2182^2, or 0.0476, should be homozygous. This means that 82 per cent are heterozygous, and might be expected to show signs of reduced pigmentation, a little lower than expected on the 3-chromosome model.

The 2-chromosome model therefore fits the data adequately provided that the albolabiate allele can vary in expression from completely recessive through co-dominance to complete dominance. It avoids the alternative requirement of a second mutation or an unusual recombination event. The test would be to carry out a breeding programme with individuals from this colony crossed to snails from colonies with uniform full pigmentation.

DISCUSSION

Cain *et al.* (1968) showed that samples of *C. nemoralis* from the Pyrenees and Ireland containing fully pigmented and unpigmented lips also had pale-lipped individuals at frequencies compatible with their being heterozygous. These authors also provided breeding data showing albolabiate to be an allele at the P locus which produces pale-lipped heterozygotes. The present data derived from morph frequencies in a natural population suggest that albolabiate homozygotes might sometimes have slightly pigmented lips, and that at the other extreme some albolabiate heterozygotes may have completely white lips. If so, the allele shows extremely broad expressivity. Although Stratton (1958) described his findings under the title "*Two unusual snail colonies*" he may not have realized how unusual the implications of the frequencies actually were.

The homologous condition in normally white-lipped *C. hortensis* is for occasional colonies to be polymorphic for pigmented lip. The coloration is variable. Taylor (1914) refers to named varieties *luteolabiata* Cockerell 1887, *roseolabiata* Taylor 1883 and *fuscolabris* Kreglinger 1870. In order to recognise further variants he coined three new names: *violaceolabiata*, *nigrolabiata* and *bimarginata* (Taylor, 1914). He also emphasises that the darker shades are unstable and may fade rapidly after death. The gene or genes concerned in this species may likewise show variable expressivity.

The population genetics of *Cepaea* continues to be of interest because the reasons for the shell colour and banding polymorphisms have not been generally agreed (Cook, 1998). Since we do not have definite answers it is worth continuing to examine data from the field. Moreover, the large number of surveys carried out in the 1960s and earlier allow comparisons to be made to detect systematic changes and possible environmental causes (e.g. Murray and Clarke, 1978; Arthur *et al.*, 1993; Cook & Pettitt, 1998; Cook *et al.* 1999 ; Cameron, 2001; Bellido *et al.*, 2002). In the present case re-collection was made after a lapse of 44 years. At first sight the samples from the 1960s suggested that a rare genotype might be in the process of rapid elimination. Instead, the current frequencies of the main types are now almost exactly what they were at the beginning, providing no evidence of random or selective change. Mid-banded may, however, be declining.

The data from the intermediate period, when the species was rare, suggest that relative visibility may be much more biassed when density is low than when it is high. By the same token, visual selection may be more extreme when predation is hurried than when it is deliberate, emphasising again the reactive nature of selective predation.

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HABITATS OF *VERTIGO MOULINSIANA* (GASTROPODA: VERTIGINIDAE) IN CORNWALL

GERALDINE A. HOLYOAK[1]

Abstract *In Cornwall large numbers of* Vertigo moulinsiana *were obtained from short herb-rich fen vegetation using quantitative sampling methods. Smaller numbers were obtained from the more usual reedswamp habitats nearby, by beating stems over a tray. Occurrence of* Vertigo moulinsiana *in short herb-rich vegetation has implications for our understanding of its habitat requirements and for the choice of sampling techniques.*

Key words Vertigo moulinsiana, *habitats, sampling techniques, Cornwall*

INTRODUCTION

The status, distribution and habitat requirements of *Vertigo moulinsiana* (Dupuy, 1849) were recently reviewed by Drake (1999) using information obtained largely from records submitted to the Conchological Society's recording scheme, and extensive surveys commissioned by English Nature. Typically *V. moulinsiana* has been found close to rivers or in the wettest areas of fens where the tall plants on which the snails live are in standing water or at least on saturated ground (Drake 1999). In 2000 a population of *V. moulinsiana* was discovered new to Cornwall, at Penhale in a reedswamp habitat dominated by *Phragmites australis* growing in a dune-slack. In January 2001 a second Cornish site for *V. moulinsiana* was discovered at Perranporth, again in reedswamp dominated by *Phragmites*. They were found using similar methods of sampling to those outlined by Drake, by beating vegetation over a tray and sweep-netting.

Further sampling at the Penhale site using different techniques was undertaken during 2001 as part of a wider study of land snails and in the hope of finding other *Vertigo* species. Surprisingly this revealed larger numbers of *V. moulinsiana* living in short and long herb-rich fen vegetation types which differed strikingly from the usual habitat requirements described for the species. This paper describes the habitats of the species at Penhale in Cornwall in detail and considers the implications for our understanding of the habitat requirements of *V. moulinsiana* more generally.

METHODS

Five sites at Penhale Sands, West Cornwall (SW 78-57-) were initially selected for sampling on 27 January 2001 to represent the main vegetation types present: (1a) grassy upper edge of fen with *Juncus inflexus;* (1b) edge of fen grassland in small area dominated by *Iris pseudacorus*; (2) short grassy and herb-rich fen with *Festuca rubra* and *Salix repens;* (3) tall herb-rich fen with *Filipendula ulmaria* and *Iris pseudacorus*, and (4) tall fen vegetation dominated by *Carex paniculata.*

At each sampled site *ca* 5 litres of material was taken from a representative square metre by cutting the vegetation at ground level. This was then dried, sieved and sorted to extract all snails (and some slugs). The Mollusca were identified and counted.

Another visit on 18 August 2001 was used to record vegetation details for the sampled

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[1] 8 Edward Street, Tuckingmill, Camborne, Cornwall, TR14 8PA.

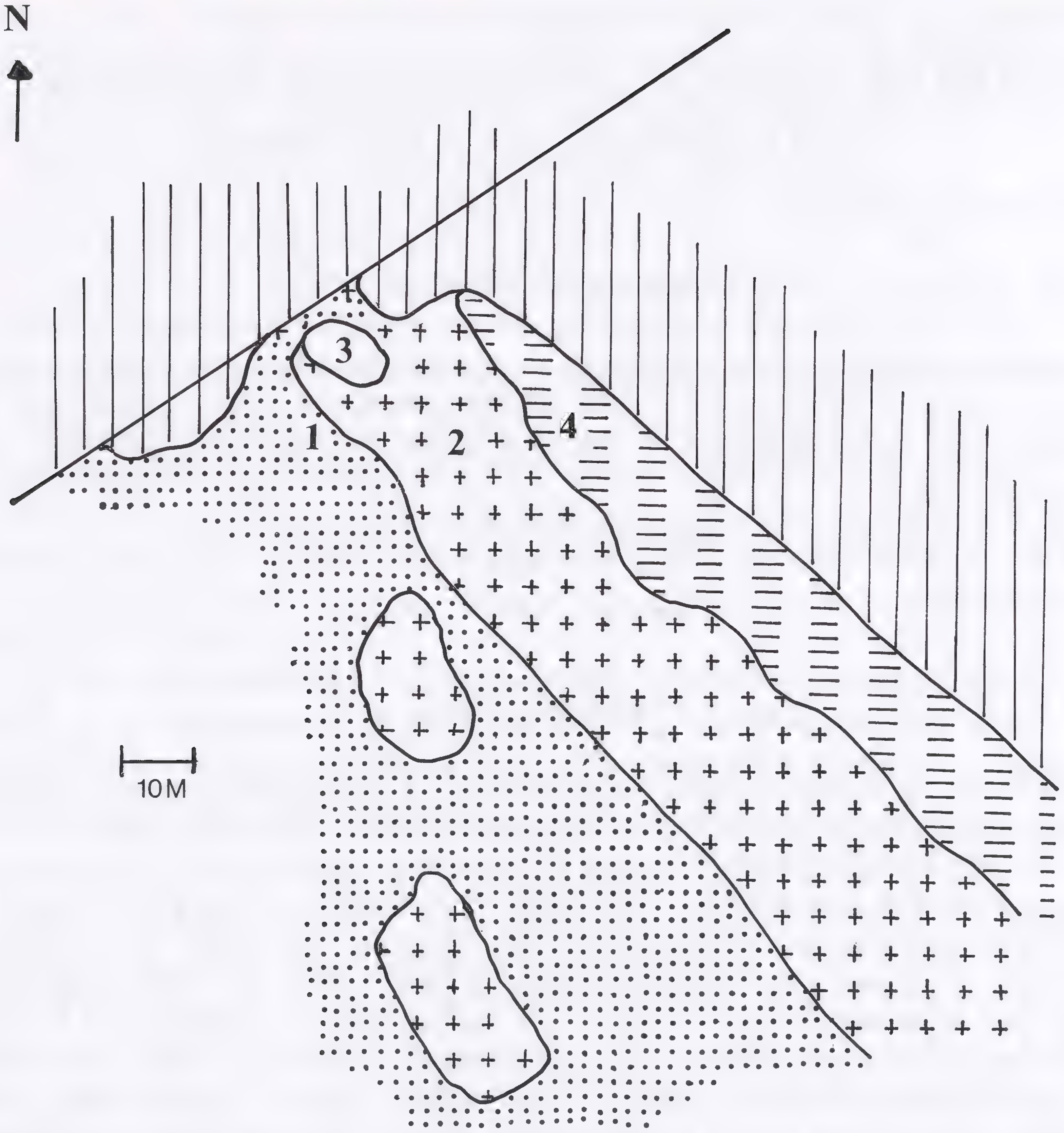

Figure 1 Schematic map of study area at Penhale Sands, Cornwall, showing locations of the sampled sites in relation to vegetation types. 1: grassy upper edge of fen with *Juncus inflexus*; 2: short grassy and herb-rich fen with *Festuca rubra* and *Salix repens*; 3: tall herb-rich fen with *Filipendula ulmaria* and *Iris pseudacorus*; 4: tall fen vegetation dominated by *Carex paniculata*. For detailed data on vegetation at the sites at which *Vertigo moulinsiana* occurred see Table 2.

sites with *V. moulinsiana.* This was carried out at a time of year when vegetation height and biomass are at their maximum and most vascular plant species are readily identified. A representative 2 x 2 m quadrat area was chosen to survey vegetation at each site. The vegetation data were assigned to the types described in the National Vegetation Classification (NVC) (Rodwell 1991a-2000).

In October 2002 additional vegetation samples (*ca* 5 litres) were taken from sampled sites 2 and 4, and processed in the same manner as described above, except that only *V. moulinsiana* was extracted and counted. A schematic map and a cross-section drawing of the vegetation types were made (Figs 1 and 2). Photographs were also taken of sites 2 and 4 (Figs 3 and 4).

In this paper nomenclature of: Mollusca follows Kerney (1999); vascular plants follow Stace (1997); and bryophytes follow Blockeel & Long (1998).

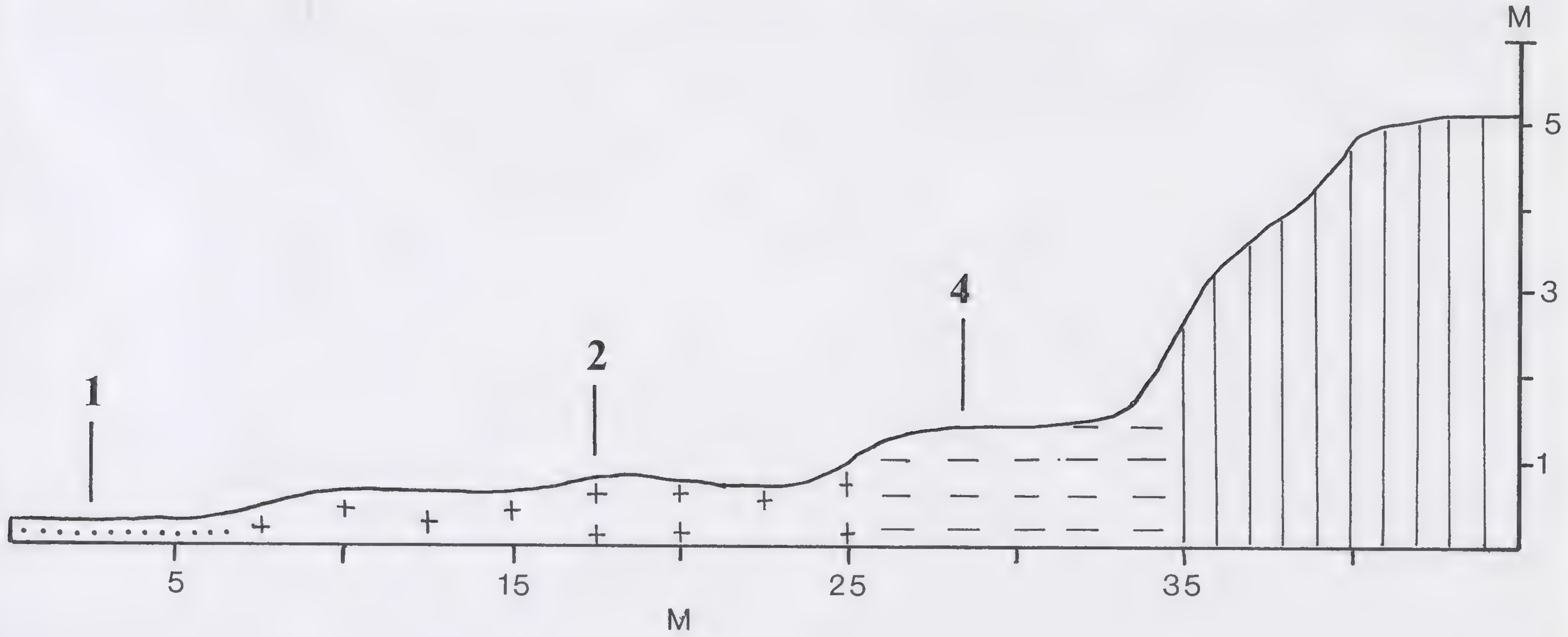

Figure 2 Schematic cross-section showing the location of sampled sites and the height of vegetation at Penhale Sands, Cornwall. For description of vegetation types see legend to Figure 1.

RESULTS

Vertigo moulinsiana was found at three of the sampled sites on 27 January 2001 (Table 1). It is notable that at site 2 *V. moulinsiana* accounted for 43% of Mollusca, with 143 individuals (immature and mature). Although also present at sites 3 and 4, *V. moulinsiana* was found in much smaller numbers. At site 4, it represented only a small fraction of the total number of snails. There was little difference in species richness of Mollusca recorded at any of these three sites. Further samples taken in October 2002 at sites 2 and 4 again both contained *V. moulinsiana.* At site 2, there were 36 living adult and immature specimens extracted; at site 4 there were 9 living adult and immature specimens.

A schematic map (Fig. 1) and cross-section (Fig. 2) illustrate the locations of the sampled sites in relation to the vegetation types and photographs taken at site 2 (Fig. 3) and site 4 (Fig. 4) show the character and height of the vegetation.

Table 2 gives detailed data on the vegetation for each of the three sites where *V. moulinsiana* occurred. Site 4 has features expected in *V. moulinsiana* habitats, with rather tall vegetation consisting mainly of tussocks of *Carex paniculata*. Site 3 also has tall vegetation, but dominated by herbs including much *Iris pseudacorus* and *Filipendula ulmaria*. In contrast, site 2 has rather low vegetation lacking the taller reedswamp plants, being instead a herb-rich fen grassland, yet it was this site that held much the largest numbers and highest density of *V. moulinsiana.* In terms of the NVC classification, site 2 corresponds to SD15 (*Salix repens - Calliergon cuspidatum* dune-slack: Rodwell 2000) although *Salix repens* is rather sparse; site 3 corresponds to M27 (*Filipendula ulmaria - Angelica sylvestris* mire: Rodwell 1991b); site 4 corresponds to S3 (*Carex paniculata* sedge-swamp: Rodwell 1995).

DISCUSSION

It is generally thought that the habitat requirements of *V. moulinsiana* are well understood and consist essentially of tall 'reedswamp' vegetation dominated by narrow-leaved monocots (Pokryszko 1990, Drake 1999). Large sedges (*Carex* spp.), *Glyceria*

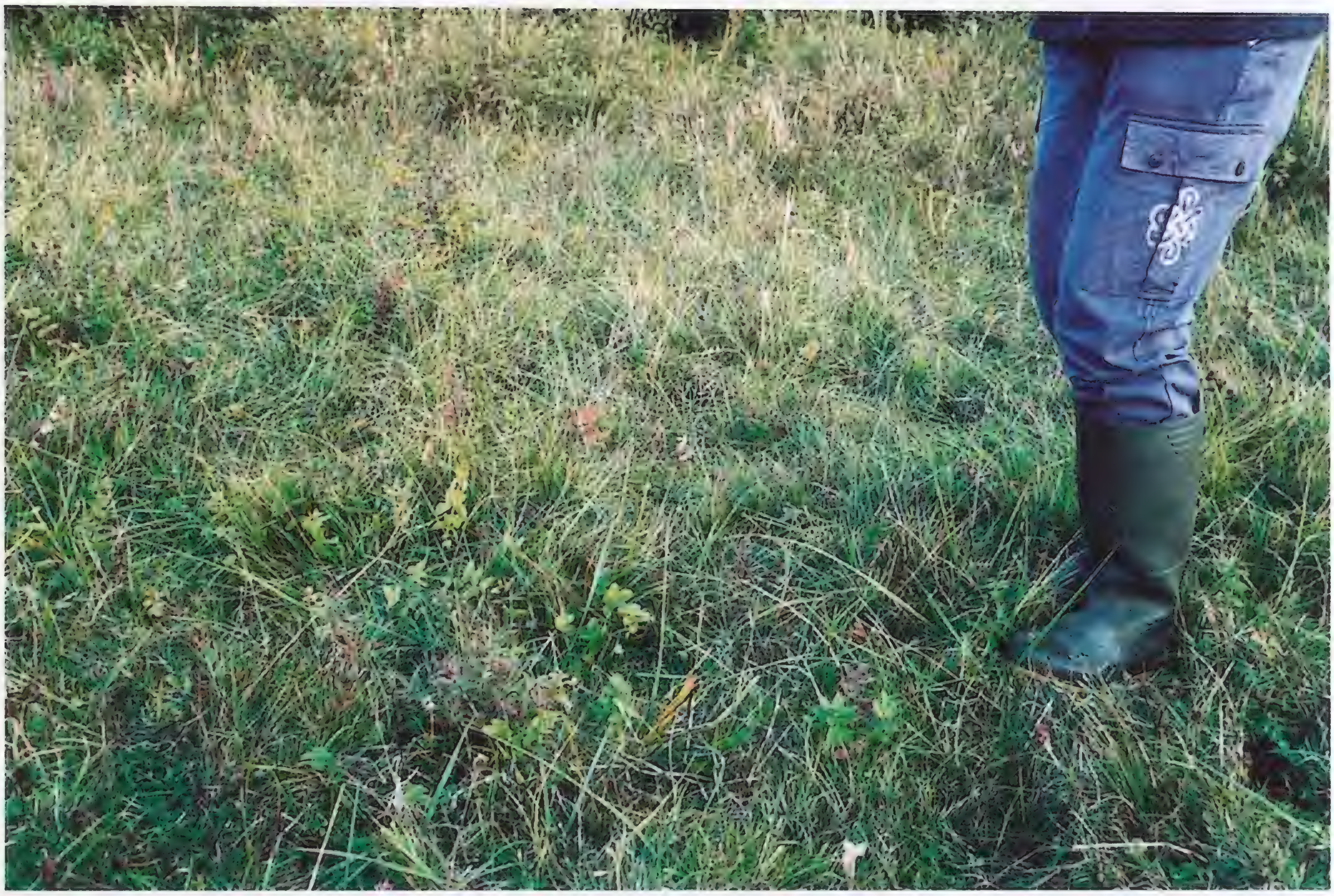

Figure 3 Sampled site 2 at Penhale Sands, Cornwall showing short vegetation in the grassy and herb-rich fen habitat where *Vertigo moulinsiana* was most abundant.

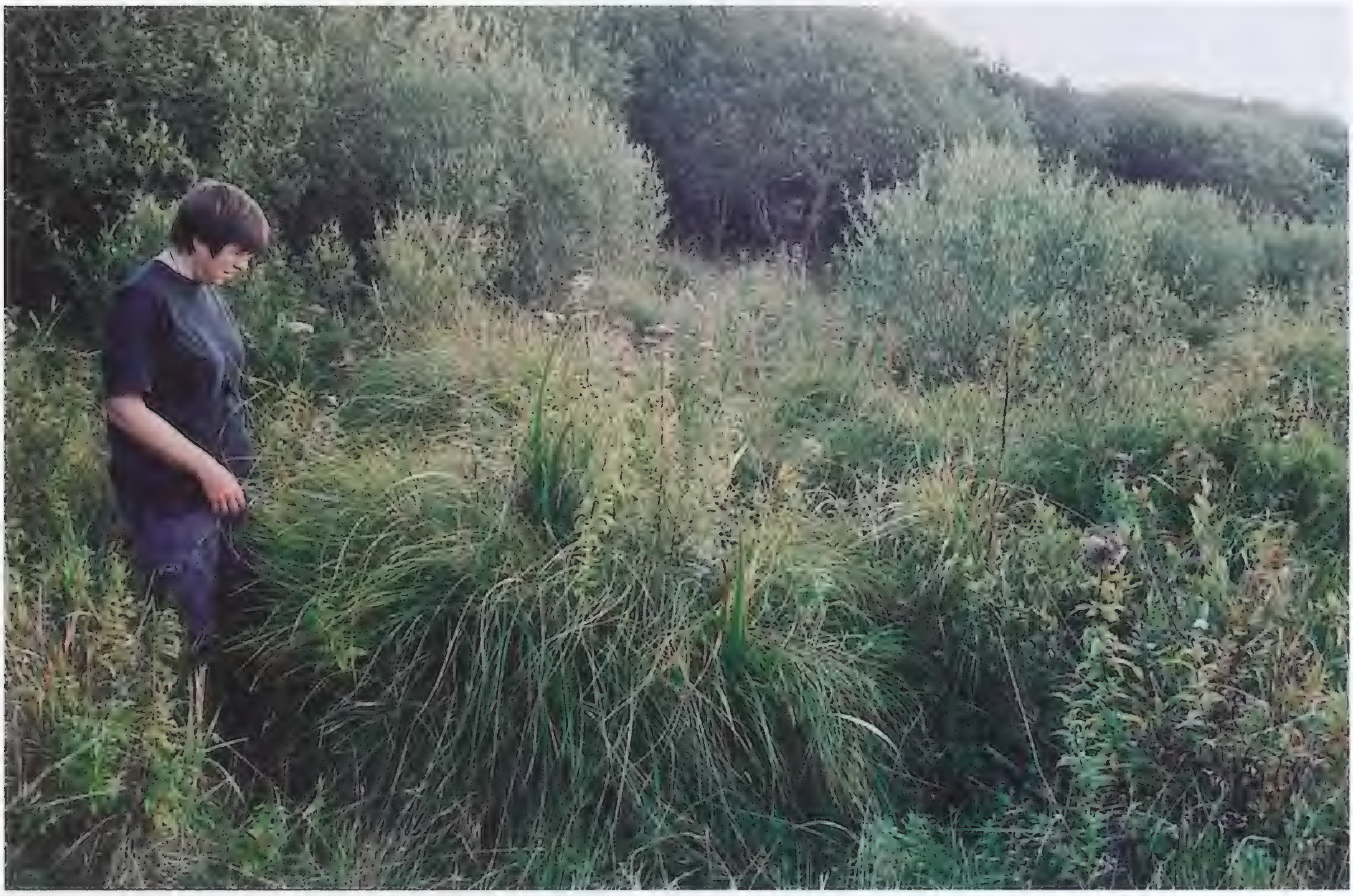

Figure 4 Sampled site 4 at Penhale Sands, Cornwall showing the tall fen habitat dominated by *Carex paniculata* where low numbers of *Vertigo moulinsiana* were found.

TABLE 1

Counts of Mollusca from quantitative samples collected at Penhale Sands, Cornwall, January 2001

Site number	**1a**	**1b**	**2**	**3**	**4**
Carychium minimum	-	-	1	8	2
Carychium tridentatum	-	-	-	20	-
Carychium sp.	-	-	-	6	-
Oxyloma pfeifferi	-	-	18	3	5
Cochlicopa lubrica	5	6	2	7	2
Cochlicopa sp.	9	4	7	55	13
Vertigo antivertigo	-	-	1	1	1
Vertigo pygmaea	-	-	48	45	-
Vertigo moulinsiana	-	-	143	11	8
Vallonia excentrica	-	-	3	-	-
Vallonia sp.	-	-	3	-	-
Punctum pygmaeum	-	-	-	19	-
Vitrea crystallina	-	-	-	4	-
Nesovitrea hammonis	4	14	3	2	-
Aegopinella nitidula	1	12	1	5	1
Aegopinella pura	-	-	3	-	-
Oxychilus alliarius	4	7	-	7	2
Oxychilus helveticus	-	-	-	-	4
Zonitoides nitidus	1	1	1	4	3
Deroceras laeve	-	-	2	5	3
Euconulus alderi	-	-	9	17	-
Ashfordia granulata	7	5	41	25	-
Trichia hispida	6	15	18	3	7
Cepaea sp.	1	11	1	1	4
Total	38	75	305	248	55

maxima or *Phragmites australis* are the most commonly recorded dominants, and other records are from stands of *Iris pseudacorus, Phalaris arundinacea* or *Typha* spp. These vegetation types correspond to NVC types S2-7, S12-13, S17, S24-26 and S28 of Rodwell (1995). However, detailed study of vegetation zonation and molluscan distribution at Wheatfen Broad, Norfolk, by Ellis (1941) revealed that *V. moulinsiana* occurred there in a somewhat wider range of vegetation types. The species colonised the early-successional *Typha angustifolia* stands growing in shallow water (corresponding to NVC type S13 of Rodwell 1995), flourished through later reedswamp stages dominated by *Phragmites* and then by *Glyceria maxima* (= NVC types S4 and S5 of Rodwell 1995), and persisted in residual stands of these monocots as they became shaded in 'swamp-carr' (= NVC woodland types W1 or W6 of Rodwell 1991a). He also found *V. moulinsiana* in an area of *Juncus subnodulosus* fen (= M22 of Rodwell 1991b) with abundant growth of the shrub *Myrica gale*, and persisting in relict patches of ground vegetation in 'fen-carr' (woodland dominated by oak *Quercus robur* and ash *Fraxinus excelsior*).

In reedswamps *Vertigo moulinsiana* occurs on the stems of tall vegetation at about 30-50 cm above the ground or water surface, descending to the ground in the late autumn and remaining there until early spring (Pokryszko 1990). In reedswamp habitat this snail has often been surveyed by holding a tray low down in the tall vegetation and beating the stems over the tray, any snails which are on the leaves and stems thus being dislodged onto the tray (Drake 1999). This survey technique was used successfully by me to find *V. moulinsiana* in tall *Phragmites*-dominated vegetation at the original (2000) site at Penhale and at Perranporth in 2001. However, it would not have been feasible to use it on the shorter fen vegetation (site 2), which quantitative sampling revealed as being the habitat which contained the majority of *V. moulinsiana*. In this habitat the mean height of vegetation was only 20 cm, there was no standing water or saturated ground, and the plants involved are characteristic of drier fen environments. This site

TABLE 2
Vegetation data from 2 x 2 m quadrats with *Vertigo moulinsiana* at Penhale Sands, Cornwall, August 2001

Site number	**2**	**3**	**4**
Vegetation height (cm) mean	20	70	80
maximum	96	124	174
% bare soil	<1	5	2
% cover: vascular plants			
Angelica sylvestris	-	7	2
Caltha palustris	2	-	2
Carex flacca	3	-	-
Carex nigra	12	-	-
Carex paniculata	-	-	65
Centaurea nigra	-	3	-
Cerastium fontanum	-	<1	-
Dactylorhiza praetermissa	-	-	<1
Epilobium parviflorum	-	2	<1
Equisetum fluviatile	11	3	2
Equisetum palustre	10	10	-
Eupatorium cannabinum	-	-	12
Euphrasia nemorosa	1	-	-
Festuca rubra	14	<1	-
Filipendula ulmaria	3	32	4
Holcus lanatus	4	-	-
Hydrocotyle vulgaris	3	-	2
Hypericum tetrapterum	<1	2	<1
Iris pseudacorus	-	20	-
Lotus pedunculatus	1	<1	1
Lychnis flos-cuculi	<1	-	<1
Lythrum salicaria	1	-	1
Mentha aquatica	1	-	-
Menyanthes trifoliata	7	-	-
Pedicularis palustris	2	-	-
Phragmites australis	-	2	2
Poa trivialis	-	<1	-
Prunella vulgaris	<1	-	-
Pulicaria dysenterica	2	8	3
Ranunculus acris	1	1	1
Ranunculus flammula	2	-	-
Rhinanthus minor	2	3	1
Rumex conglomeratus	-	1	-
Salix repens	2	-	-
Trifolium pratense	8	-	-
Trifolium repens	<1	-	-
% cover: bryophytes			
Calliergonella cuspidata	8	-	-

is subject to shallow flooding for short periods in some winters, but it is not regularly inundated and was not flooded in the 2000/2001 winter. Using accepted criteria for the habitat preferences of *V. moulinsiana*, site 2 at Penhale would have been judged to be at best a marginal habitat adjacent to more suitable habitat (at site 4 - see Figs 1 and 2). However, the high numbers of both immature and mature snails found at site 2 show clearly that this was their preferred habitat at this locality. Seasonal or other lateral movement of *V. moulinsiana* from tall vegetation (site 4) to the short vegetation (site 2) can be discounted because these sampled sites are at least 10 m apart.

Drake's (1999) summary of much of the survey work undertaken in recent years on *V. moulinsiana* in England revealed that it is more widely distributed than previously thought and that large populations can be found along the banks of several major river systems. It thus seemed that the habitat requirements of *V. moulinsiana* could be 'tightly defined' (Drake 1999 p. 74) as being 'in the wettest areas where the tall plants on which they live are standing actually in water or on saturated ground', mainly in reedswamps along rivers.

Nevertheless, older information, such as that in Ellis (1941) emphasises the breadth of habitat types tolerated by *V. moulinsiana*. Unfortunately, many of the former areas with natural habitat transitions from reedswamp through fen to grassland, or from reedswamp through carr-scrub to woodland were destroyed long ago in southern and central England. In their place we are left with abrupt transitions from reedswamp to managed grassland or to dry woodland, and in this setting *V. moulinsiana* will indeed be largely restricted to the reedswamp and unable to demonstrate its ability to occupy a wider range of habitat types.

The data from Penhale would suggest that at least some populations of *V. moulinsiana* may be overlooked if searching is restricted to a narrow range of reedswamp habitats. These findings thus have implications for our understanding of the habitat requirements and total distribution of *V. moulinsiana*, and for the choice of techniques if truly comprehensive surveys of the species are attempted.

ACKNOWLEDEMENTS

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THE GENERA *SIMPLICIFUSUS* AND *GRANULIFUSUS* (GASTROPODA: FASCIOLARIIDAE) WITH THE DESCRIPTION OF TWO NEW SPECIES IN *GRANULIFUSUS*

MARTIN AVERY SNYDER[1]

Abstract *The genus name* Simplicifusus *is treated as a subjective junior synonym of the genus name* Granulifusus. *The species previously assigned to* Simplicifusus *are enumerated and discussed. The species assigned to* Granulifusus *are enumerated and two new species are described in this genus,* Granulifusus vermeiji *and* Granulifusus dondani, *both collected in the Philippine Islands.*

Key words *Mollusca, gastropod, Fasciolariidae,* Simplicifusus, Granulifusus, *new species, Philippine Islands.*

INTRODUCTION

This paper discusses two related fasciolariid genera: *Simplicifusus* and *Granulifusus*. Species assigned to both these genera are enumerated and those assigned to *Simplicifusus* are discussed. *Simplicifusus* is concluded to be a subjective junior synonym of *Granulifusus*. The name of the Pliocene subspecies of *Fusinus simplex* (E.A. Smith, 1879), *Granulifusus simplex* ssp. *pauciliratus* Shuto, 1962 is herein changed to *Fusinus pauciliratus*, based upon priority.

Two new species are described in the genus *Granulifusus*, both from the Philippine islands. *Granulifusus vermeiji* is compared to the fossil species *G. matsumotoi* Shuto, 1958 and *G. dualis* Yokoyama, 1928, both from the Pliocene of Japan. *Granulifusus dondani* is compared to *G. hayashii* Habe, 1961 and *G. kiranus* Shuto, 1958, both Recent members of the genus.

Abbreviations for museums and collections are as follows:

ANSP	Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, USA
BMNH	British Museum of Natural History (The Natural History Museum), London, United Kingdom
HC	Hadorn collection, Roethenbach, Switzerland
MNHN	Muséum national d'Histoire naturelle, Paris, France
SC	Snyder collection, Villanova, Pennsylvania, USA

THE GENERA *SIMPLIFUSUS* AND *GRANULIFUSUS*

The genus name *Simplicifusus* was first proposed (in an unavailable publication) by Kuroda (1949), was subsequently used by Kira (1962:85) but with no description (see Bieler and Petit (1996:33)), and introduced validly by Kuroda and Habe (1971:184, 282) with the type species *Fusus simplex* E.A. Smith, 1879 (as *Fusinus*). *Fusus simplex* E.A. Smith, 1879 is apparently known only from the immature holotype (BMNH 1874.12.11.158), collected at a depth of 15 m south of Korea (34°8'N 126° 24'E). Because of problems of homonymy this species was renamed *Fusinus complex* Snyder, 2000. Shuto (1962:60) named a Pliocene subspecies from Japan, *Granulifusus simplex* ssp. *pauciliratus*. This

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[1] Department of Malacology, Academy of Natural Sciences of Philadelphia, 19th and Benjamin Franklin Parkway, Philadelphia, PA 19103, USA.

species is apparently also known only from the type specimen in the Department of Earth and Planetary Sciences, Kyushu University, Fukuoka, Japan (GK-L6172) collected from Miyazaki Prefecture, Kyushu. I have examined both type specimens and they are indeed closely related, but as noted by Shuto (1962:60) *G. simplex* ssp. *pauciliratus* has fewer spiral cords than in Smith's *F. simplex*. It is sensible to maintain these two subspecies as distinct at this time. The correct name of this taxon is *Fusinus pauciliratus*; it can be divided into two subspecies: *Fusinus pauciliratus pauciliratus* (Shuto, 1962) (Pliocene) and *Fusinus pauciliratus complex* Snyder, 2000 (Recent).

Most published illustrations identified as *Fusinus simplex* are in fact of a larger (40 mm-50 mm) species, distinct from Smith's species, as recognized by Habe after an examination of the holotype of *Fusinus simplex*. Habe (Habe and Masuda, 1990:121) states that "the so-called Japanese specimens are not agree [sic] with the true *Fusinus simplex* (E.A. Smith, 1879),... . Therefore this Japanese form is a different species...". This would include the type material for the Kuroda and Habe genus *Simplicifusus*; their published illustration is clearly of *Fusinus noguchii*. In 1999, when I wrote the paper which noted this fact (2000:175-176), the resolution of a type based upon misidentified material required submission of the problem to the International Commission on Zoological Nomenclature. Under the new code (article 70.3) this matter can be resolved here and hence I fix the type species of *Simplicifusus* as *Simplicifusus noguchii* Habe and Masuda, 1990 by first reviser's choice.

Granulifusus was proposed as a genus name by Kuroda and Habe (1952:59) but with no description (see Garrard (1966:7)). It was introduced validly by Kuroda and Habe (1954:89) with the type species (by monotypy) *Fusus niponicus* E.A. Smith, 1879. The two shell characteristics cited in the original description of this genus are a granulated surface sculpture and a small round operculum which does not fill the aperture. Shuto (1958) characterized shells of this genus as having convex angulated whorls with strong axial ribs and distinct spiral cords with numerous intermediate spiral lines. The whorls of *Granulifusus* are sculptured with strong axial ribs and usually rather wide-set spiral cords, producing a granulose surface. Most species are light brown with the spiral cords often reddish brown. Keys to the Recent species are given by Delsaerdt (1995).

An examination of *Fusinus noguchii* reveals both a small rounded operculum which does not fill the aperture as well as granulated surface sculpture (on many specimens). I conclude that *Fusinus noguchii* should be placed in the genus *Granulifusus* and that *Simplicifusus* is a subjective junior synonym of *Granulifusus*. This placement was first proposed (with the misidentification *Fusus simplex*) by Shuto (1962:60).

The other species that have been placed in the genus *Simplicifusus* are:
Fusus graciliformis G.B. Sowerby, II, 1880
Fusinus hyphalus M. Smith, 1940
Pseudolatirus pallidus Kuroda and Habe *in* Habe 1961
Fusinus (*Simplicifusus*) *guidonis* Delsaerdt, 1995
Trophon muricatoides Yokoyama, 1920

The first two species in this list appear to be atypical *Fusinus*. *Pseudolatirus pallidus* appears to be a true *Pseudolatirus* and *Simplicifusus guidonis* may be a *Pseudolatirus* as well. *Trophon muricatoides* is the type species of the genus *Trophonofusus* Kuroda and Habe, 1971, an apparently distinct genus.

The genus *Granulifusus* consists of nine Recent species and two subspecies together with four fossil species, as follows:
Fusus captivus E.A. Smith, 1899. (Recent, Andaman Islands).
Granulifusus consimilis Garrard, 1966. (Recent, western Pacific).
Fusus dualis Yokoyama, 1928. (Pliocene, Japan).
Granulifusus hayashii Habe, 1961. (Recent, western Pacific).

Granulifusus kiranus Shuto, 1958. (Pliocene/Recent, western Pacific).
Granulifusus koyuanus Shuto, 1958. (Miocene, Japan).
Fusinus makiyamai Otuka, 1937. (Pleistocene, Japan).
Granulifusus matsumotoi Shuto, 1958. (Pliocene, Japan).
Fusus niponicus E.A. Smith, 1879, type of *Granulifusus*. (Pliocene/Recent, western Pacific).
Fusinus niponicus ssp. *musasiensis* Makiyama, 1922. (Pliocene/Recent, Japan).
Granulifusus niponicus ssp. *suboblitus* Pilsbry, 1904. (Recent, Japan)
Simplifusus noguchii Habe and Masuda, 1990. (Recent, Japan).
Granulifusus poppei Delsaerdt, 1995. (Recent, east Africa).
Fusus rubrolineatus Sowerby, II., 1870. (Recent, South Africa).
Fusus? rufinodis von Martens, 1901. (Pliocene, Ryukyu Islands; Recent, east Africa).

Recent tangle net collecting in deep water off the Philippine Islands has brought to light two new species of *Granulifusus* which are now described.

SYSTEMATIC DESCRIPTION

FASCIOLARIIDAE

Subfamily Fusininae Wrigley, 1927
Genus ***Granulifusus*** Kuroda and Habe, 1954
Granulifusus vermeiji n.sp.
Figs 1-4

Holotype Collected off Aligbay Island, northwest of Dipolog, Mindanao, Philippine Islands, at 150 m in tangle nets, ANSP 410027.

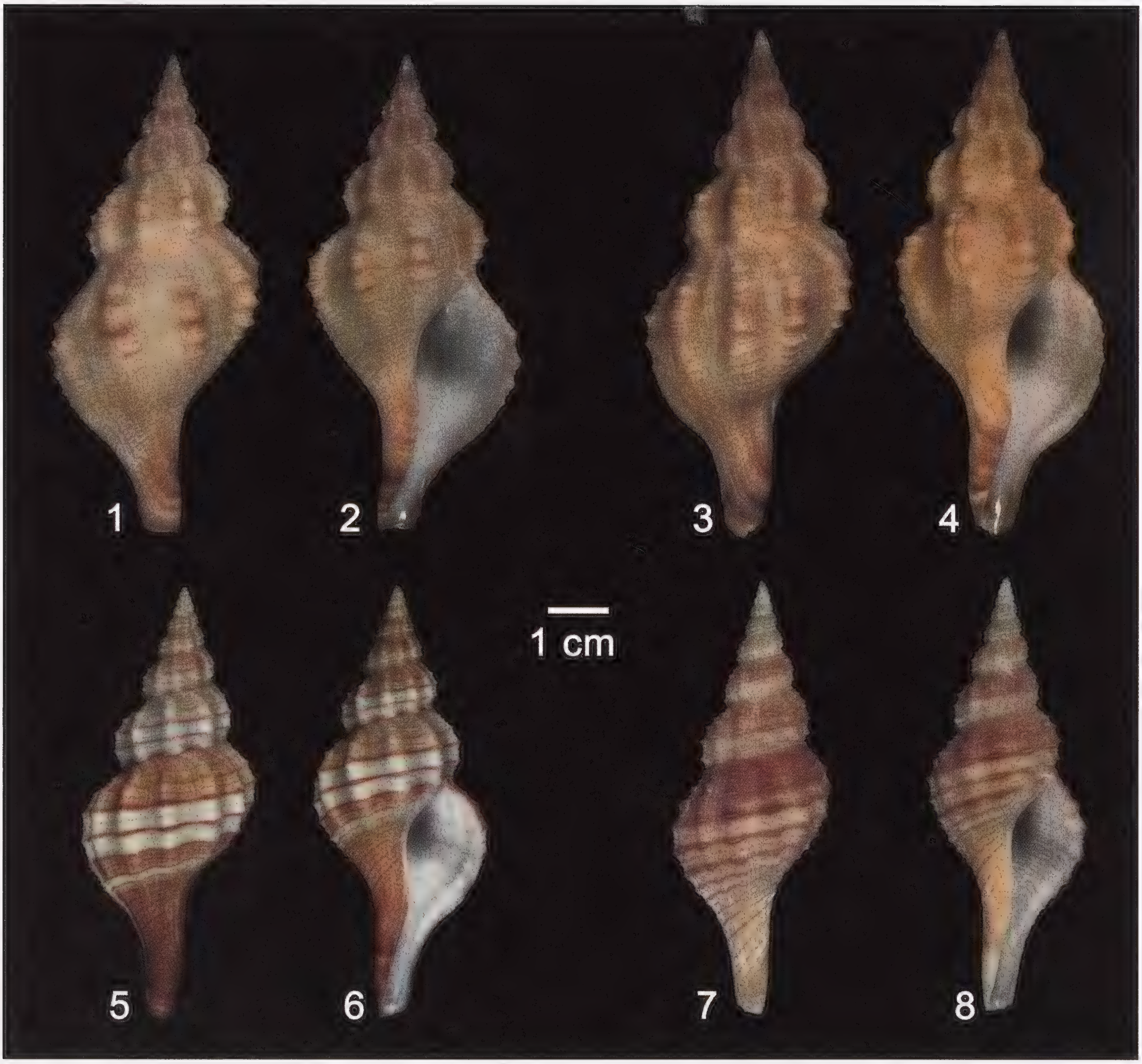
Paratypes Paratype 1, in tangle nets at 160 m, Balicasag Island, Bohol, Philippine Islands, MHHN; paratype 2, in tangle nets, Punta Engano, Mactan Island, Philippine Islands, SC; paratype 3, in bottom tangle nets at 200 m, Balicasag Island, Bohol, Philippine Islands, SC; paratype 4, in tangle nets at 550 m, Balicasag Island, Bohol, Philippine Islands, HC.

Shell Measurements Holotype: length 53.4 mm, greatest diameter 24.1 mm, paratype 1: length 56.8 mm, paratype 2: length 46.1 mm, paratype 3: length 49.5 mm, paratype 4: length 56.3 mm.

Other Material Examined Two additional specimens, one mature at 52.6 mm and one immature at 36.4 mm, were examined (both SC). These specimens were collected from the type locality.

Type locality Off Aligbay Island, northwest of Dipolog, Mindanao, Philippine Islands.

Description Shell broad for genus, size about average, length to 56.8 mm. Protoconch shiny brown, smooth, 1–1-¼ whorls, diameter on holotype .85 mm. Teleoconch of 8 whorls, sculpture of prominent axial ribs, 8 on penultimate and body whorl, 10 on next to penultimate whorl and 12 on earlier whorls; whorls crossed by 4 strong spiral cords on first teleoconch whorl, cords added adapically with 7 strong spiral cords on body whorl. Additional prominent cords developed between these strong cords, with 3 intermediate cords on penultimate and body whorl. Numerous axial lines form surface texture



Figs 1, 2 Holotype shell of *Granulifusus vermeiji*, n. sp.; **Figs. 3, 4** Paratype 1 of *Granulifusus vermeiji*, n.sp., 56.8 mm; **Figs. 5, 6** Holotype shell of *Granulifusus dondani*, n. sp.; **Figs. 7, 8** Paratype 2 of *Granulifusus dondani*, n.sp., 48.3 mm

divided roughly into squares. Background color whitish to pale beige, brown early whorls, brown where central strong longitudinal cords cross ribs, with brown streaks from last few ribs extending up siphonal canal to color canal dark brown. Columella shiny white, smooth, with a few pale brown stripes, wrapping from the canal. Aperture and inner lip bright shiny white with lirations, labral margin brown.

Derivation of name This species is named for Geerat J. Vermeij, Department of Geology, University of California, Davis.

Comparisons *Granulifusus vermeiji* is unlike any other Recent *Granulifusus* and is placed in this genus provisionally since no soft parts or operculum have been seen. It follows the general shell morphology of the genus but is exceptionally broad compared to other living members of the genus. This breadth is reminiscent of the early Pliocene *Granulifusus matsumotoi* Shuto, 1958 from Japan. *G. matsumotoi* has a height: largest diameter ratio of approximately 2.8 compared to 2.21 in holotype for *G. vermeiji*, but it attains a height of just 33 mm and has 10-11 axial ribs. *Granulifusus dualis* Yokoyama, 1928 from the Pliocene of Japan exhibits a similar height to largest diameter ratio but again is quite small (a large specimen attaining 37.5mm). This species also has more axial ribs than *G. vermeiji.*

Granulifusus dondani n.sp.

Figs 5-8

Holotype Collected off Balicasag Island, Bohol, Philippine Islands, at 140 m in tangle nets, ANSP 410028.

Paratypes Paratype 1, in tangle nets at 140 m, MNHN; paratype 2, in tangle nets at 160 m, SC; paratype 3, in tangle nets at 140 m, SC; all paratypes from type locality.

Shell Measurements Holotype: length 48.1 mm, greatest diameter 19.2 mm, paratype 1: length 44.2 mm, paratype 2: length 48.3 mm, paratype 3: length 41.8 mm

Other Material Examined 16 mature and 5 immature specimens were examined (all SC); mature specimens range in length from 38.4 mm to 50.4 mm. These specimens were collected throughout the central Philippine Islands.

Type locality Off Balicasag Island, Bohol, Philippine Islands.

Description Shell fusiform, average size for genus, biconic, thin. Whorls convex and inflated. Protoconch pearly white, smooth, 1¼ – 1½ whorls, diameter on holotype .6 mm. Teleoconch of 8 whorls, sculpture of promient axial ribs, 10-13 in number (11 on holotype), varying little from whorl to whorl, whorls crossed by 3-4 strong spiral cords on early whorls , 4-5 on penultimate whorl (4 on holotype), and 16 strong cords on body whorl of holotype; cords are added apically. Weaker cords between strong ones, with one central one stronger than others and often colored. Strong cords brown against varying background color of white, grey, tan and light brown. There are two distinct color forms of this species (see figs. 5, 6 and 7, 8). First form with shell color in bands, with transition from one color band to another occuring at a strong cord. Second form with more uniform tan and light brown bands, also with fewer cords on siphonal canal, although that seems to be the only morphological differentiation between the color forms. Aperture oval, narrow, elongate toward the siphonal canal. Lip weakly dentate, interior of aperture shiny white with minor brown tinge at labral margin. Margin smooth about 1 mm; inside of lip then corded 8 mm-9 mm into interior with prominent raised cords; columella smooth.

Derivation of name This species is named for Don Dan, Ft. Meyers, Florida.

Comparisons *Granulifusus dondani* can be distinguished from *G. niponicus* by the white nodules on the latter species. The surface sculpture on *G. dondani* is not so sharp and well defined as in *G. niponicus*. *G. hayashii* is larger (to 79.1 mm) with a more slender profile and more distinct nodules than in *G. dondani*. *G. poppei* is also more elongate then *G. dondani* and the intermediate spiral cords are all of equal strength. Finally, *G. kiranus* is larger (to 70.5 mm) and often has more (15-20) axial ribs on the body whorl. Of the specimens examined about 60% are the banded “form” (like the holotype). These color forms may represent sexual dimorphism of this species.

ACKNOWLEDGEMENTS

Gary Rosenberg offered helpful suggestions. The digital plate was photographed and composed by Sarah Watson.

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PISIDIUM MOITESSIERIANUM PALADILHE, 1866, REDISCOVERED IN IRELAND

In Ireland, the pygmy pea mussel, *P. moitessierianum* has not been recorded for nearly eighty years, and appears to have always been an uncommon species. The latest Atlas (Kerney 1999)[1] shows living records from seven 10km squares: 3 from the Shannon system, one each from the Rivers Barrow and Suir, the Grand Canal in west Dublin, and the Lagan Canal in Co. Antrim. Additional Postglacial fossil records indicate that it was formerly more widespread in the Shannon, Suir, Nore and Barrow river systems. Most of these records were by Phillips[2] and Stelfox[3] with the most recent record dating back to 1924. On this basis, the species was considered to be extinct in Ireland.

In November 2002 we found living individuals of *P. moitessierianum* in the Grand Canal, at two sites east of Tullamore, County Offaly (10km square N32). The Grand Canal at these locations supported a diverse aquatic mollusc fauna comprising 19 gastropods species and 8 bivalves. The associated *Pisidium* species were *P. amnicum, P. casertanum, P. subtruncatum, P. henslowanum* and *P. nitidum.* At both locations *P. moitessierianum* appeared to be relatively uncommon, with less than 10 live individuals amongst several hundred *Pisidium* specimens. The zebra mussel, *Dreissena polymorpha* (Pallas, 1771) was also common at both sites. Since the first Irish record in 1997[4], it has spread rapidly in the Shannon system and has now entered the Grand Canal and will, no doubt, continue to expand eastwards.

The absence of any records of living specimens since the 1920s raises the question as to whether *P. moitessierianum* has always been present since that the time, but has merely been overlooked, or whether it is a relatively recent recolonist. It is, however, surprising that it was not refound during the periods of intensive recording, particularly in the 1970s, for the Society's non-marine Census. Studies are currently underway to determine the species' current status in both the Grand and Royal Canals.

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Ian J. Killeen
163 High Road West,
Felixstowe
IP11 9BD
email: Ian@malacserv.demon.co.uk

Evelyn A. Moorkens
40 Templeroan Avenue,
Dublin 16,
Ireland
email: evelynmoorkens@eircom.net

GANULA LANUGINOSA (BOISSY) AND OTHER ADDITIONS TO THE FAUNA OF IBIZA

The extant nonmarine Mollusca of Ibiza, Pityuse Islands, Spain, is listed by Paul[1], and with a subsequent single addition by Norris *et al.*[2], comprises 37 terrestrial and 12 fresh or brackish-water species.

On a recent visit to the island (July 2001), a total of 22 live and 6 dead terrestrial species were recorded. Among these were 2 live adults and 1 juvenile of the hygromiid *Ganula lanuginosa* (Boissy), found under storm debris in a dried out stream bed at Siesta, Santa Eulalia. This species has been reported from the islands in the main Balearic group, Mallorca[3] and Menorca[4], but not from Ibiza. On Ibiza it may exist sparingly along streambanks or by irrigation ditches where suitable cover is available.

Four juveniles of a milacid slug species were encountered in watered apartment gardens at Santa Eulalia. The individuals were small (<0.5cm) and coloured a uniform mealy or yellowish-brown except for dark tentacles and abbreviated but distinct black lateral bands on the mantle. These were reared to maturity and then dissected, proving to be typical *Milax gagates* (Draparnaud). I can find no reference to banding, juvenile or otherwise, in this species, but juveniles of similar appearance have been seen in Mallorca (Sa Porrassa, April 1989).

In the same gardens two juveniles of a limacid slug with uniform peach-brown integument and short dark bands on the posterior of the mantle, were found. These were reared and dissected and proved to be another common Balearic species *Lehmannia valentiana* (Férussac)[5]. The notable feature here was the complete absence of lateral bands in adults which were an unmarked pinkish-brown colour with yellow-brown overtones on the mantle. Banding is almost universal in my experience of Balearic and British Isles material of this species[6].

Several juvenile *Deroceras* were recorded under pots in a garden centre on the southern outskirts of Santa Eulalia. These were dissected and identified as *Deroceras panormitanum* Lessona & Pollonera. *D. panormitanum* is unknown in the Balearics[4] but may have been overlooked in places such as garden centres. At the same site a large number of adults and juveniles of a succineid were found and again reared and dissected. These were identifiable as Oxy*loma elegans* (Risso) (= *pfeifferi* sensu auctt. Brit.). Paul[1] could not assign historical succineid records for Ibiza with any certainty and lumped them under *Oxyloma pfeifferi,* although he suggested that more than one succineid might be present. Finally, several empty shells of a small zonitid were also collected under pots. These were identified as *Zonitoides arboreus* (Say), a N. American shell of cosmopolitan status, but also new for the Balearic Islands.

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Roy Anderson
Dept. of Agricultural & Environmental Science
Queen's University
Newforge Lane
Belfast
BT9 5PX

COLONIAL AESTIVATION IN THE IBIZAN ENDEMIC *VITREA GASULLI* RIEDEL & PAULS

The Ibizan endemic *Vitrea gasulli* Riedel & Paul, 1978, is a little known species whose original description was based upon dead shells[1]. Norris *et al.*[2] described the internal anatomy but were able to base this on only a small number of fresh specimens (4 in all) from two localities, Cala d'Aubarca and Santa Eulalia del Rio (type locality). The species is widespread on Ibiza, with sixteen sites reported by Norris *et al.*, but appears to be very elusive in the living state.

In July 2001, during a visit to Ibiza in hot summer weather, I managed to collect in excess of 370 live animals at two localities. The first of these was Santa Eulalia which is located on the estuary of a seasonal stream. The stream was completely dry, and had been for some time, at the time of the visit. Two aggregations of *gasulli* (68 and 31 individuals respectively) were found on the underside of large stones (~30kg mass) in partially shaded conditions on the stream bed. Shells were closed by thick, rust-brown, epiphragms which also cemented them to the stone under-surface. The colonies were at first mistaken for a mineral encrustation, like fine crystal outgrowths from the stone, because of their small size and close aggregation.

A few km to the south, at Cala Longa Bay, further accumulations of aestivating animals were encountered. South-facing slopes and slightly open sites such as forest clearings in this area produced only dead shells but live animals were found on steep north-facing slopes within *Pinus halepensis* forest. The largest single colony, of a total of four, had 175 individuals, with about 280 individuals seen altogether. As at Santa Eulalia, colonies were found under moderate-sized boulders in shade. It was clear, from the range of stone sizes available compared to those actually selected for aestivation, that a minimum or critical mass (or perhaps depth of stone) was needed to protect the colonies from the heating and desiccating effects of the sun, despite the partial shade. *Lauria cylindracea* (Da Costa) was frequent in the same micro-sites as *V. gasulli* but did not appear to be aestivating. Thus the *Lauria* became active soon after their removal from stones but the *Vitrea* were inactive for some days and a number did not emerge for fully two months after collection.

The behaviour described above is probably not unique among Mediterranean *Vitrea* but I have been unable to find reference to it in other species.

1 RIEDEL A. & PAUL C.R.C. 1978 *Boln Soc. Hist. nat. Baleares* **22**: 54–60.
2 NORRIS A., PAUL C.R.C. & RIEDEL A. 1988 *J. Conch.* **33**: 43–48.

Roy Anderson
Dept. of Agricultural & Environmental Science
Queen's University
Newforge Lane
Belfast
BT9 5PX
UK

REVIEWS

Olive shells: the genus and the species problem by Bernard Tursch and Dietmar Greifeneder 2001, published by L'informatore Piceno (C.P. 421 – 60100 Ancora, Italy) pp 569. ISBN 88.86070.17.9. Cost approx. £80 Hardback.

On first seeing this book my initial thought was to wonder whether another book on Olive shells was really necessary. It did not take long using the book to convince me that not only was a new book on the subject justified, but that this work was by far the most comprehensive revision of the genus to date.

The authors have spent some twenty years studying Olives in depth, including extensive field work, examination of all available type material, examination of some 30,000 specimens and over 100,000 measurements in 3,000 specimens, together with aquarium observations and experimentaation – I found the method of measurement of radula growth and the shell colour change resulting from transferring animal from a dark substrate to a light substrate particularly interesting. The extent of this background research may be gauged by the fact that the authors have published some 36 papers on Olives during this period of study. This thorough preparation ensures that this book is both comprehensive and authoritative.

Olive shells are highly variable in colouration and it has long been a vexed question among students of the group exactly what constitutes a valid species. The authors set out to resolve this 'species problem' and look at different methodds of classification before their more detailed study of the group. This preliminary section of the work could be usefully studied by anyone interested in Molluscan taxonomy – irrespective of whether that interest extends to Olives or is limited to any other group.

Following the section on the species problem the authors look in detail at, among other things, the anatomy of Olives, the structure of the radula, reproduction, feeding methods and preferences, ecology, collecting methods – including a simple shell trap which could easily be adopted by other collectors, shell structure and micro structure and shell colour and patterns – particularly looking at the polymorphisms which result from the cryptic colouration of both shell and animal depending on the colour of the substrate. This colour variation has led to much confusion through great intraspecific variation and interspecific convergencce where different species living on the same substrates develop similar colouring that the authors term a 'local colour palette'.

At the core of the book each species recognised as valid is discussed over two or three pages which includes a detailed description of the species emphasising those characteristics most important for identification, comments on the animal, habitat preference and distribution. Each species account incorporates a distribution map and an illustration of the species annotated to point out important characteristics. Similar species are grouped together for ease of comparison, and there are some 15 tables to help differentiate the species in each group, although no taxonomic significance is placed on these groups.

Nomenclature receives detailed coverage in the section 'le tombeau des Olives' – confusingly, if poetically, titled in French when the text is in English. Here for each taxon the authors give full-page references to the original descriptionn, location of type specimens, an indication of whether the taxon is considered a valid species, subspecies or colour form or should be considered a synonym, nomen nudem or nomen dubium. For valid taxa a list of synonyms is given, and helpfully the authors also indicate how each taxon has been treated by previous works on Olive shells making it easier to reconcile earlier studies with the present work.

The text is written in a relaxed, almost conversational style making what could have been a dry study easy to follow. The book is profusely illustrated throughout with diagrams and photographs, while 29 black and white plates illustrate some 296 type specimens, almost all in both dorsal and ventral view, which on their own make this an important taxonomic work. In addition some 48-colour plates illustrate some 625 specimens, again nearly always in both dorsal and ventral view, togeher with a number of living Olives. This illustration of so many multiple specimens showing variation within each species is extremely helpful for identification. A detailed twenty page bibliography is included and there is both a subject and a systematic index.

At £80, this book may not find its way on to every conchologist's shelf, although it will be absolutely essential to anyone specialising in the genus, but even for the non-specialist it wouuld be well worth borrowing a library copy. It can be highly recommended.

Kevin Brown

Süsswassergastropoden Nord- und Mitteleuropas by P. Glöer 2002, Die Tierwelt Deutschlands und der angrenzenden Meeresteile 73. Teil. Mollusca 1. Bestimmungsschlüssel, Lebenweise, Verbreitung. Conch Books, Hackenheim, 327pp., 307 figs. ISBN 3-925919-60-0. In German. Price 55 Euros.

There has, for many years, been a need for a comprehensive and up-to-date guide to the identification of freshwater gastropods. British and Irish workers have had to rely on the out-of-date and incomplete works by Macan, Ellis or Janus, or turn to continental works such as Glöer & Meier-Brook's *Susswassermollusken* on the German fauna, and the Dutch work by Gittenberger *et al, De Nederlandse Zoetwatermollusken*. This new book, *The freshwater gastropods of northern and central Europe*, provides a very welcome addition to the identification literature on this group of molluscs.

The countries covered by this work are: Iceland, Norway, Sweden, Finland, Denmark, Great Britain, Ireland, Netherlands, Belgium, Luxembourg, Germany, Austria, Switzerland, Hungary, Czech Republic, Slovakia, Poland, Lithuania, Latvia and Estonia.

The book is presented in two parts, the first, general part comprises 39 introductory pages commencing with a full systematic list followed by sections on shell features, anatomy, feeding and digestion, reproduction, ecology, dispersal, invasive/alien species, threats, collecting and curating. The second, systematic part, comprises a key to each family followed by individual species accounts. The species accounts are all written to the same formula: Name, author, date; Common or vernacular names; Selected synonymy; Type locality; Description of the shell; Biology, Ecology; Variability; Red List category (selected countries only); Distribution; Quaternary records. The accounts are supported by high quality monochrome photographs (including growth series and regional variation) and line drawings of the shells, and drawings of genital anatomy. A particularly useful feature of the work is the inclusion of a comprehensive bibliography at the end of each family section. There are 2 further reference sections at the end, one on country literature and the other on original descriptions. A small map showing the distribution of each species would have been a helpful addition.

The book describes 216 species, 193 recent plus a further 23 known only as fossils. However, the work has 2 curious omissions, whilst the marine/semi-marine *Paludinella, Otina, Mysotella* ~~etc~~ are all included, *Truncatella subcylindrica* and *Onchidella celtica* are not! Within the list, 118 species are in the family Hydrobiidae, which includes all of the central European spring snails (e.g. *Belgrandia, Bythiospeum* and *Bithynella*), the majority of which are known only from one or a handful of localities. This is the first time all of these species have been illustrated and described in a single work.

The nomenclature is likely to be unfamiliar to many British and Irish workers. It follows the recent CLECOM checklist by Falkner *et al* 2001 (*Heldia* **4**: 1-76). Whilst not all malacologists are in agreement with this, it is likely to become the European standard, and therefore we should become accustomed to it. This includes both generic and specific changes, with some of the most significant within the Lymnaeidae. We have tended to use the names *L. peregra* and *L. palustris* for everything equating to those two species complexes. For the *peregra* group, the new work uses *Radix labiata* (Rossmässler, 1835) , and *Radix balthica* (L., 1758). '*Lymnaea palustris*' comprises five species in the genus *Stagnicola* of which *S. palustris* and *S. fuscus* have been positively recorded in Britain and Ireland (see Carr & Killeen, *Journal of Conchology* **38**: 67). Other changes for species occurring in the British Isles include *Mercuria anatina* from *M. confusa*. The nomenclature for all of the other groups should be more-or-less familiar. Having said that Glöer follows the CLECOM checklist, there are at least 2 differences I have noticed. The checklist uses *Peringia ulvae* and *Obrovia neglecta*, whereas Glöer has reverted to *Hydrobia* for both species. On page 11 the following is quoted - 'taxonomic stability is ignorance', however, these nomenclatural differences between recent works are not at all helpful when they are not explained!

Overall, this is an excellent piece of work. The fact it is German should not be a deterrent, and I recommend that all malacologists and freshwater biologists working with molluscs obtain a copy.

Ian Killeen

JOURNAL OF CONCHOLOGY, VOLUME 37: INDEX

This index is in three parts: a taxonomic index, a general and geographic index and an author index. It is designed to signpost users to the article they want rather than to be a comprehensive index of every reference in the *Journal of Conchology*.

Page references are to the first page of the article concerned, except for new taxa where the page reference gives the start of the formal description.

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NEW RECORDS OF PORTUGUESE OPISTHOBRANCH MOLLUSCS

C. GAVAIA[1&3], M.A.E. MALAQUIAS[2&3], G. CALADO[3&4] & VICTORIANO URGORRI[5]

Abstract *Eleven opisthobranch species (1 Cephalaspidea and 10 Nudibranchia) collected on the southern and western coasts of Portugal are reported for the first time from the Portuguese continental coasts:* Chelidonura africana *Pruvot-Fol,1953,* Trapania orteai *García-Gómez & Cervera, 1989,* Polycera aurantiomarginata *García-Gómez & Bobo, 1984,* Thecacera pennigera *(Montagu, 1815),* Doris sticta *(Iredale & O'Donoghue, 1923),* Discodoris atromaculata *(Bergh, 1880),* Dendrodoris herytra *Valdés & Ortea, 1996,* Hancockia uncinata *(Hesse, 1872),* Doto millbayana *(Lemche, 1976),* Favourinus blianus *Lemche & Thompson, 1974 and* Eubranchus doriae *(Trinchese, 1874). Two families (Aglajidae and Hancockiidae) and three genera* (Chelidonura, Thecacera *and* Hancockia*) are new records for the Portuguese opisthobranch fauna. For each species, descriptions of external features and colour photographs are provided and the geographical distribution, external morphology and aspects of ecology are discussed.*

Key words *Opisthobranchs, Portugal, New Records*

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INTRODUCTION

Studies have been made on the opisthobranchs from Portugal since the nineteenth century, when the pioneer work of Oliveira (1895) reported 45 species from the Portuguese continental coasts. Throughout the twentieth century there were few studies concerning Portuguese opisthobranchs, apart from species reported from dredging expeditions (mainly Cephalaspideans) in malacological or more general faunistic or ecological works. A turning point in the study of Portuguese opisthobranchs was accomplished with the international marine biology expedition "Algarve 88" on the southern Portuguese coasts and the publication of its results (García-Gómez *et al.*, 1991) in which 53 additional species were reported. Recently, further information has been reported from the western coasts by Calado & Urgorri (1999) and Calado *et al.* (1999) and from the southern coasts by Malaquias & Morenito (2000). These works also provide good historical and bibliographical reviews of the study of opisthobranchs in Portugal. Although our knowledge of Portuguese opisthobranchs has clearly improved, each new survey adds additional species to the already recorded fauna. In this work we studied 11 opisthobranch species, as well as three genera and two families, which have not been reported before from the Portuguese coasts.

STUDY AREAS

The Arrabida coast is part of the central western Portuguese coast extending from Setúbal to Cabo Espichel (Fig. 1-A). It is characterised by submerged vertical walls with caves and rocky bottoms formed by the falling of boulders of variable size from the adjacent surface cliffs. These substrata are colonized by the typical invertebrate biotas of marine rocky substrates, including sponges, hydrozoans, bryozoans, gastropods,

[1] Universidade do Algarve, Faculdade de Ciências do Mar e do Ambiente, Campus de Gambelas, 8000-817 Faro, Portugal, cgavaia@hotmail.com

[2] Mollusca Research Group, Department of Zoology, The Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom, manm@nhm.ac.uk Corresponding author

[3] Instituto Português de Malacologia. Zoomarine, E.N. 125, Km 65, Guia, 8200-864 Albufeira, Portugal.

[4] Centro de Modelação Ecológica IMAR. FCT/UNL, Quinta da Torre, 2825-114 Monte da Caparica, Portugal, bagoncas@mail.telepac.pt

[5] Laboratorio de Zooloxía Mariña, Departamento de Bioloxía Animal, Universidade de Santiago de Compostela, 15706 Santiago de Compostela - ESPAÑA

bivalves, ascidians, algae and other groups. This area is strongly influenced by the estuary of the Sado river, resulting in the formation of extensive sandy deposits. Depths rarely exceed 10 meters, but can reach 17-18 meters on the edges of the Arrábida coast.
The Sagres coast is located on the western extremity of the southern Portuguese coasts (Fig. 1-B). Its characteristics are very similar to those found in Arrábida, with a predominance of rocky bottoms in beaches and groups of islets, submerged vertical walls with caves, bottom boulders of variable size and concrete boulders of artificial inlets, all colonized by typical rocky substrate communities. There are also some sand and coarse sand bottoms in beaches and bays, populated mostly by algae. The depth increases from the intertidal down to more than 30 meters, with the bottoms turning to coarse sediment or sand at about 23-24 meters. The westernmost point of this coast, Cape St. Vicente, is also the south westernmost point of the European coast and stands close to the triple convergence between the Mauritanian, Lusitanian / Boreal and Mediterranean zoogeographical regions, making this coast particularly interesting in terms of species composition and certainly worthy of further faunistic and biogeographical studies.
The Ria Formosa is located further east on the southern coast, in front of the cities of Faro and Olhão (Fig. 1-C). It is a vast coastal lagoon with approximately 55 km of extension and a surface area of 10 000 ha, bounded to the south by a barrier system comprising a series of islands and peninsulas with several inlets that establish communication

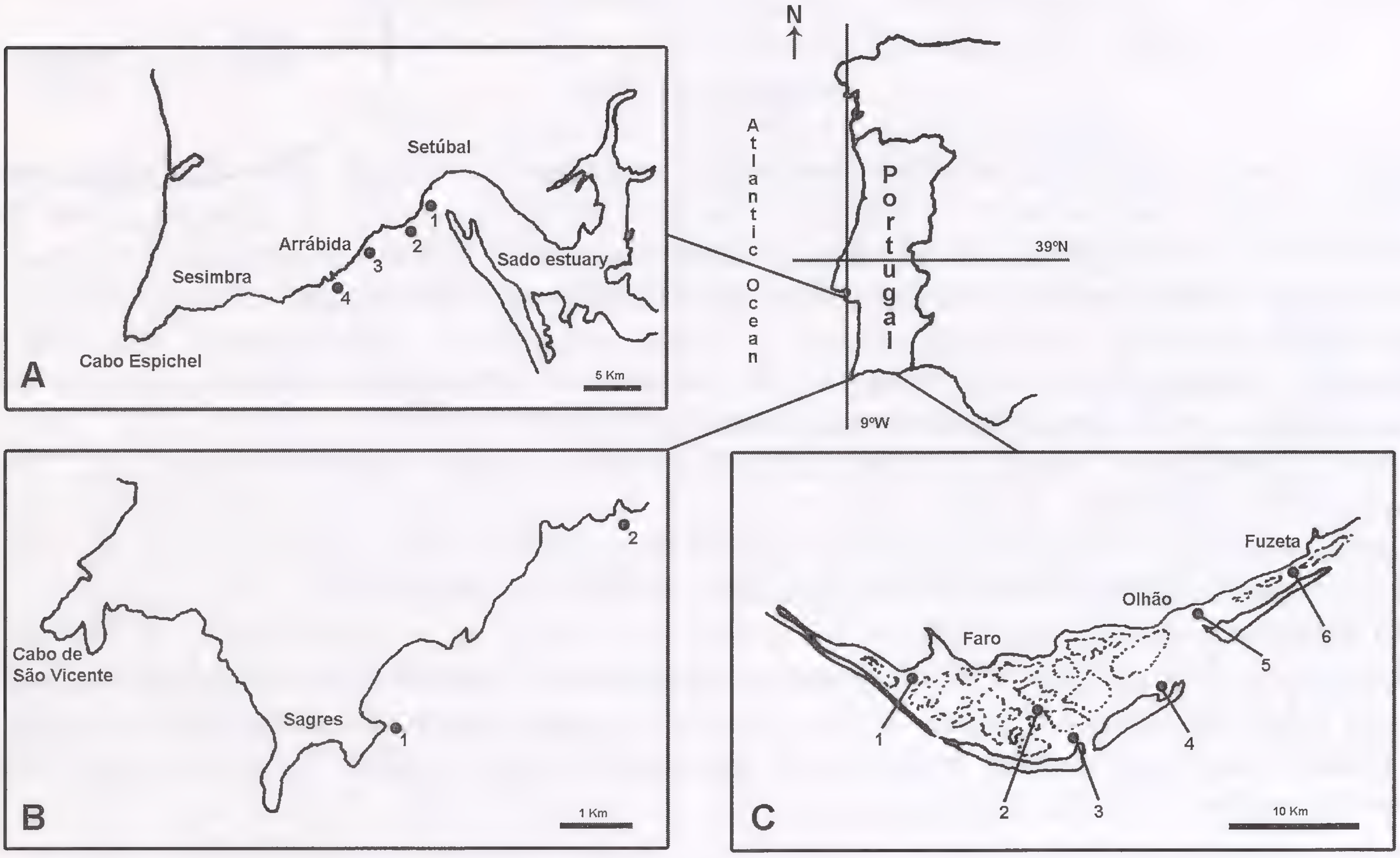

Figure 1 Maps of the study areas, with collection sites. A - Arrábida coast: 1 - Comenda (Arflor) (38º30´18´´N, 8º55´18´´W); 2 - Rampa da Secil (Outão) (38º29´36´´N, 8º55´42´´W); 3 - Três Irmãs (38º27´48´´N, 8º59´24´´W); 4 - Pedra da Águia (38º27´18´´N, 9º00´30´´W). B - Sagres coast: 1 - Ponta da Baleeira, cliffs adjacent to the Baleeira fishing harbour (37º00´55´´N, 8º55´53´´W); 2 - Praia da Ingrina (37º02´48´´N, 8º53´65´´W). C - Ria Formosa: 1 - Canal do Ramalhete, near the biological station of the Universidade do Algarve (37º00´31´´N, 7º88´43´´W); 2 - Esteiro dos Cações (36º59´40´´N, 7º52´50´´W); 3 - Ilha da Culatra, near Hangares (36º58´49´´N, 7º51´41´´W); 4 - Ilha da Culatra, northeastern extremity (37º00´08´´N, 7º49´20´´W); 5 - Canal de Marim, close to the boarding pier of the Ria Formosa Natural Park (37º01´44´´N, 7º49´19´´W); 6 - Canal de Bias (37º02´19´´N, 7º46´25´´W).

with the sea. Calvário (1995) defined the existence of five different habitats in the Ria Formosa, namely sand, sandy mud, muddy sand, mud, and seagrasses (*Zostera noltii*, *Z. marina* and *Cymodocea nodosa*). Due to artificial concrete inlets rocky substrata and associated communities are also present. Average depth is 3-4 meters but it can increase to 20 meters in some channels as well as in the major inlets.

MATERIALS AND METHODS

All specimens were collected on intertidal and subtidal surveys conducted in these areas between May 1999 and August 2001. Intertidal surveys were made under submerged and exposed conditions while subtidal surveys involved SCUBA diving down to a maximum depth of 11 meters in Arrábida, 22 meters in Sagres and 14 meters in the Ria Formosa. Sampling effort was focused on different kinds of substrata (fine or coarse sand, mud, sandy mud, rocks and boulders), vertical rocky walls with variable slopes and lighting conditions, underwater caves and also submerged artificial structures like the pillars of boat piers and large concrete boulders of artificial inlets. These substrata were normally colonised by benthic organisms where opisthobranchs are likely to occur, such as sponges, hydrozoans, bryozoans, bivalves, tunicates, algal assemblages and monospecific or mixed seagrass fields (*Zostera marina*, *Zostera noltii* and *Cymodocea nodosa*), the latter often colonised both by epibenthic animals and algae. Collection methods involved direct manual capture as well as indirect methods including collection of intertidal and subtidal substrate samples for sorting in the laboratory, brushing of intertidal rocks, and aspiration of subtidal bottoms and algal assemblages into a 1mm mesh bag using an air suction device connected to an air tank. In the laboratory, substrate samples were sieved in salt water and carefully observed under a stereomicroscope in order to separate and collect the animals. Collected material from brushing and suction was divided into several trays containing salt water and left untouched until oxygen depletion occurred, causing the smaller and cryptic species to crawl to the surface in search of oxygen. All specimens were photographed (with some exceptions in Arrábida), measured, studied *in vivo* under the stereomicroscope and identified to species level. Afterwards, they were anaesthetised with magnesium chloride dissolved in sea water, fixed in neutralised 10% formaldehyde and preserved in 70% ethanol. Voucher specimens from Arrábida were deposited in the Instituto Português de Malacologia (IPM) and in the Laboratorio de Zooloxía Mariña of the Universidade de Santiago de Compostela (LZM / USC), while the specimens from Sagres and the Ria Formosa were deposited in the Museo Nacional de Ciencias Naturales de Madrid (MNCN).

RESULTS AND DISCUSSION

Listed below are the 11 opisthobranch species studied which are reported for the first time from the Portuguese coasts (1 Cephalaspidea and 10 Nudibranchia), with two families (Aglajidae and Hancockiidae) and three genera (*Chelidonura*, *Thecacera* and *Hancockia*) also being new for the Portuguese opisthobranch fauna. Data are provided concerning sites, dates and depths of collection, the type of bottom and biota present in each site, the number and lengths of the specimens collected and also the number of those observed but not collected. For each species, a description of external features is included and also a discussion of its geographical distribution, external features and ecology. Colour photographs of the specimens studied are also provided in plates I and II. The systematic classification used is the one proposed by Cervera *et al.* (1988).

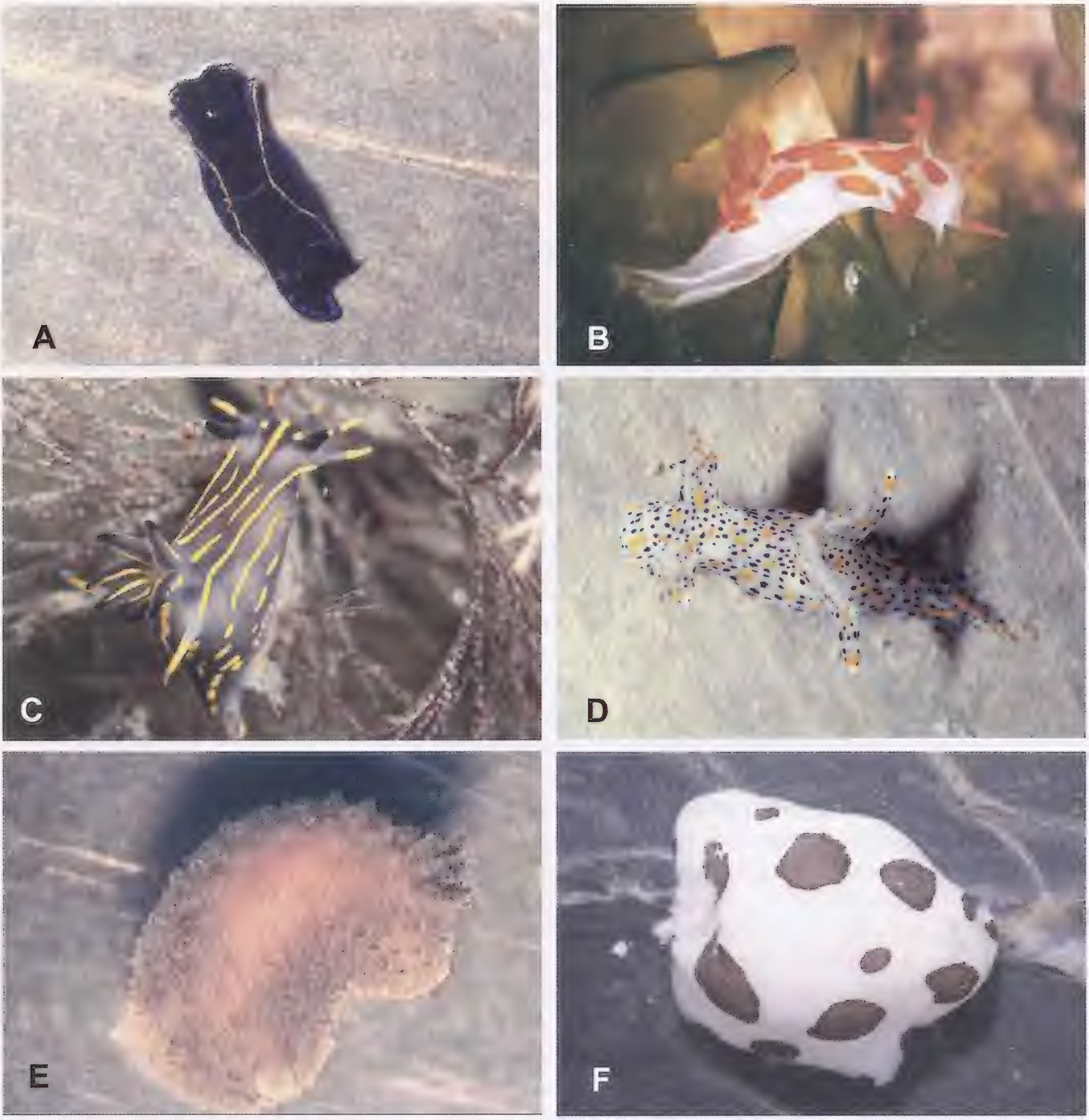

Plate I A. *Chelidonura africana* (15 mm); B. *Trapania orteai* (25 mm); C. *Polycera aurantiomarginata* (20 mm) feeding on *Bugula neritina*; D. *Thecacera pennigera* (22 mm); E. *Doris sticta* (6 mm); F. *Discodoris atromaculata* (35 mm).

CLASS GASTROPODA Cuvier, 1797
SUBCLASS OPISTHOBRANCHIA Milne-Edwards, 1848
ORDER CEPHALASPIDEA Fischer, 1883
FAMILY AGLAJIDAE Pilsbry, 1895
Chelidonura africana Pruvot-Fol, 1953
(Plate I, figure A)

Studied material C4, 05/06/01, mud bottom populated by *Z. marina*, *C. nodosa* and the algae *Ulva* sp. and *Gracilaria* sp., 3 m depth, one specimen (15 mm - MNCN 15.05/46493) on fronds of *Ulva* sp.; C5, 15/06/01, 3-4 m depth, one specimen (13 mm - MNCN 15.05/

46488) on sandy mud bottom with benthic organisms and seagrasses.

Description The body is elongated, rectangular, and smooth. The cephalic shield is slightly triangular, about half the length of the body, with the other half comprising the mantle and pallial lobe. The frontal margin of the cephalic shield is slightly bilobed with groups of short hyaline sensory bristles on the sides. The pallial lobe is divided into two long flattened triangular lobes which move independently, with the left lobe broad and nearly twice as long as the right lobe. The parapodial lobes extend along the sides of the body, from the latero-frontal regions below the cephalic shield down to the basal region of the pallial lobe. Dorsally they are very narrow and elongated with the margins clearly separated from one another, covering only the lateral regions of the cephalic shield and mantle, while ventrally they form the animal's foot and the basal regions of the pallial lobes. The ground colour of all the body is black with dark blue reflexions, with some minute superficial yellow spots all over the body surface, mostly dispersed, but some concentrated in small irregular minute patches in the centre of the cephalic shield. The anterior and posterior margins of the cephalic shield have numerous superficial white spots. In the frontal margin these are much denser and form a broad continuous band that is hyaline light blue at the corners. There are also a few white spots scattered on the surface of the mantle, pallial lobes and foot. Behind each of the hyaline blue corners of the cephalic shield, there is a pair of elongated transverse patches, one just below these regions composed of yellow spots and the other shorter and directly below the former composed of cobalt blue spots, which also occur dispersed on the posterior margins of the cephalic shield and mantle. The parapodial lobes are bordered throughout by a continuous orange band, which is itself bordered internally by a discontinuous line of elongated cobalt blue spots. This pattern is repeated on both pallial lobes, but in these the outer orange band is reduced to a few orange spots.

Discussion This species has been reported from the Mediterranean including Italy, Malta, along the southeastern Spanish coast and in the Gibraltar Strait. Atlantic reports include Morocco (Temara, original type-locality) and more recently the Canary Islands and the archipelagos of Madeira and Azores (see Martinez *et al.*, 2001). This report represents the most western one in Europe and the first for its Atlantic coasts.

Our specimens agree with the general characters described and illustrated in specimens from Morocco (Martínez *et al.*, 2001), Gibraltar Strait (García & García, 1984: 78-80), southern Mediterranean coasts of Spain (Martínez *et al.*, 1993: 22, 29), Malta (Perrone and Sammut, 1997: 63, 68), Canary Islands (Ortea *et al.*, 1996: 218-219, 229), and Madeira (Malaquias *et al.*, 2001: 79). The Mediterranean reports from Italy, Malta and the southern Spanish coasts all refer to the species *Chelidonura italica* Sordi, 1980 but this name should be regarded as a junior synonym of *C. africana* (see Martinez *et al.*, 2001 for a review on the taxonomic identity of the species). However there seems to be considerable variation in the extent of the white or yellow pigmentation, which is denser on the dorsum of most of the specimens illustrated in these works. According to Ortea *et al.* (1996) this pigmentation increases in density with increasing length, however in our 13-15 mm specimens it was concentrated mostly on the white bands that border the cephalic shield, and only sparsely dispersed over the dorsum, although they were both fully grown adults (Cervera *et al.*, 1988, referring to *C. italica*, state that adults of this species rarely exceed 10 mm). In the specimen illustrated in Martínez *et al.* (1993: 29) this pigmentation is also very sparse, being almost absent on the dorsum. Moreover, the yellow or orange lines running on the edge of the pallial lobes, described and illustrated in the specimens from Malta, Morocco, Canary Islands and Madeira, were reduced to a few orange spots in our specimens, and are not mentioned at all in those from the southern Mediterranean Spanish coasts and Gibraltar Strait. The species seems to show geographical variation in the dorsal colour pattern, with southern Iberian specimens having reduced light

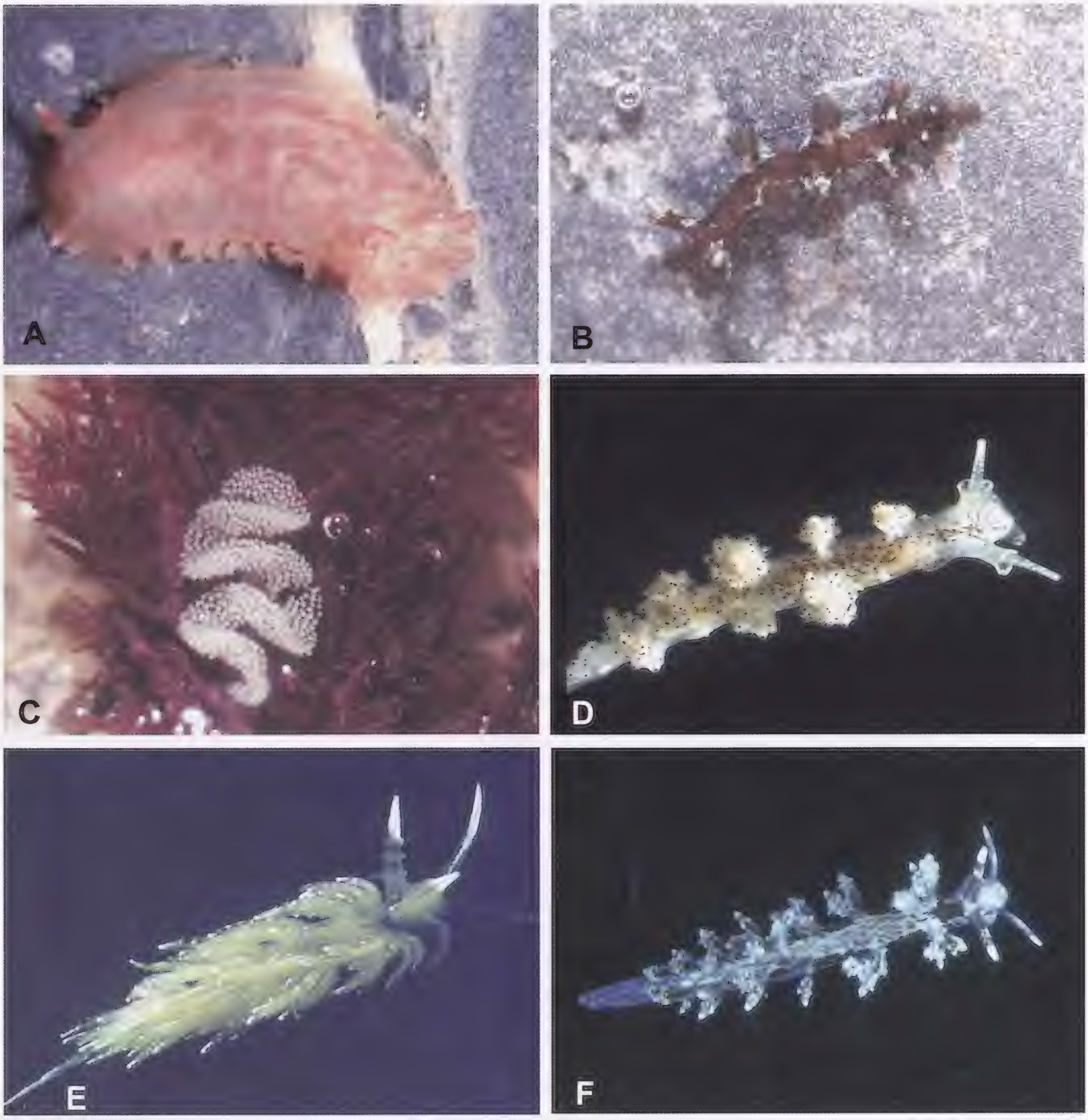

Plate II G. *Dendrodoris herytra* (25 mm); H. *Hancockia uncinata* (6 mm); I. Egg mass of *H. uncinata* on *Plocamium cartilagineum*; J. *Doto millbayana* (8 mm); K. *Favourinus blianus* (9 mm); L. *Eubranchus doriae* (9 mm).

pigmentation dorsally and yellow or orange pigmentation bordering the pallial lobes. However, this generalisation can only be established safely when more specimens, in particular from the southern Iberian Peninsula, have been studied.

Only two individuals were found in our surveys, on different occasions, although Perrone & Sammut (1997) state that this is a gregarious species, which occurs mostly in masses along the coast. Both specimens were collected at about 4 meters depth, in mud and sandy mud bottoms populated by the seagrasses *Zostera noltii* and *Cymodocea nodosa*, the algae *Ulva* sp. and *Gracilaria* sp. and also benthic animals including sponges, hydrozoans, polychaetes, gastropods, ascidians and other groups. This agrees in general with what is known of the ecology of this species, since it has been consistently found in algal communities of shallow waters and has been reported on brown algae, on *Vaucheria* cf. *turettii*, on formations of *Cymodocea* and *Caulerpa* where accumulations of *Jania rubens* are present (see Perrone & Sammut, 1997), with other specimens being found on red and calcareous algae and on *Posidonia oceanica* (see Martínez *et al.*, 1993). According to Martínez *et al.* (1993) the Aglajidae live on soft bottoms, where individuals can bury and hide, and are voracious predators of other marine invertebrates including nemertinines, polychaetes, molluscs and other opisthobranch species. However, the same authors state that *C. africana* (referring to *C. italica*) lives on rocky substrates rich in algae and marine invertebrates, with reports of specimens from the Mediterranean Spanish coasts feeding actively on small planarians (Templado & Talavera, personal communication *in* Martinez *et al.*, 1993). Ortea *et al.* (1996) state that all of their specimens were also found on rocky substrates, but in the same work report two specimens being found on sandy mud with algae. Our findings from soft bottoms, not often reported for *C. africana*, may account for the burrowing behaviour associated with the Aglajidae. Both on soft and rocky bottoms, the consistent association with the algal and seagrass biotas appears to be an important if not a major factor in the ecology of this species, and this may be due to the protection and prey availability that these communities can provide, since they act as aggregational habitats for many benthic animals in search of settlement, shelter and food.

ORDER NUDIBRANCHIA Blainville, 1814
SUBORDER DORIDACEA Odhner, 1934
FAMÍLY GONIODORIDIDAE H. Adams & A. Adams, 1854
Trapania orteai García-Gómez & Cervera *in* Cervera & García-Gómez, 1989

(Plate I, figure B)

Studied material C1, 02/05/01, submerged intertidal field of *Z. noltii* with sandy mud bottom with benthic organisms, 1-2 m depth, one specimen (25 mm - MNCN 15.05/46490) on a sponge.

Description The body is smooth and limaciform, with the mid-region taller and broader and the posterior region tapering into a pointed tail. The foot is long and narrow. The propodium is grooved transverse and its corners form short pointed lateral processes curving backwards. There is a pair of long pointed oral tentacles. The rhinophores are perfoliate (16-17 lamellae in our 25 mm specimen), and behind their smooth bases are the eyes. There are three tripinnate gills mid-dorsally arranged in a circlet around the anus, the largest pointing forward and the remaining two pointing postero-lateraly. There are two pairs of dorsal papillae, shorter and broader than the oral tentacles, with pointed tips and curving backwards, one inserted laterally close to the rhinophores and the other laterally just posterior to the gill circlet. The genital pore is located on the right side, near the base of the branchial papilla. The ground colour in the body is white which turns hyaline white in the foot margins, propodial tentacles and the gill rachis, with the dark visceral mass showing through the dorsum in the mid-region of the body. On the white colour of the dorsum there is a superficial pattern of large orange spots, mostly elongated or irregular, and close together or sometimes fused. The tip of the tail, the branchial leaves, the whole length of the oral tentacles, rhinophores and rhinophoric papillae, and the distal two thirds of the branchial papillae are also orange.

Discussion This Atlantic species was described by Cervera & García-Gómez (1989) based on specimens from Huelva (type-locality) and Cádiz in the southern Atlantic coasts of Spain, being reported afterwards only once, also in Cádiz (Cervera *et al.*, 2000). This is the most western report of this Iberian species in Europe and in the Atlantic Ocean, and the first outside the localities cited in the original description.

Our 25 mm specimen matches the adult specimens described and illustrated by Cervera & García-Gómez (1989: 191, 195, 198), and is the largest specimen reported so far. The orange colour persists long after fixation and preservation in ethanol, as mentioned also by these authors. No data are presently available concerning the biology of this recently described species. According to Ortea *et al.* (1989) the European species of *Trapania* are solitary, active animals with active movements that are hard to find, but are occasionally found in small groups of up to half a dozen individuals during periods of maximal reproductive activity. *T. orteai* fits this characterisation since Cervera *et al.* (2000) and ourselves have found only one specimen each, although Cervera & García-Gómez (1989) collected 12 specimens on one occasion. Recently, in the south-western coast (Sines), during field work carried out on behalf of the Fauna Iberica project, we observed dozens of specimens of *T. tartanella* of different sizes under rocks, probably grouped for reproduction, but normally this species is also found only in very small numbers on the Portuguese coasts (personal observations).

FAMILY POLYCERIDAE Alder & Hancock, 1845
Polycera aurantiomarginata García-Gómez & Bobo, 1984
(Plate I, figure C)

Studied Material C1: 11/04/01, sandy mud bottom with benthic organisms, 2-3 m depth, one specimen (23 mm - MNCN 15.05/46491) on a sponge; 02/05/01, 4 m depth, one specimen (30 mm - MNCN 15.05/46492) on sandy mud bottom with benthic organisms; 07/06/01, subtidal field of *C. nodosa*, 3 m depth, one specimen (30 mm) on mud bottom with benthic organisms; C2, 10/08/01, subtidal field of *Z. marina*, 2-3 m depth, three specimens (25-30 mm) on mud bottom; C3, 01/06/01, 3-4 m, one specimen (18 mm - MNCN 15.05/46489) on sandy mud bottom with benthic organisms; C5: 24/05/01, 2-3 m depth, four specimens (15-20 mm - MNCN 15.05/46494) plus one specimen observed, all on sandy mud bottom with benthic organisms and seagrasses; 15/06/01, 3-4 m depth, three specimens (13-20 mm) plus ten specimens observed, all on large colonies of the bryozoan *Bugula neritina* and on sandy mud bottom with benthic organisms and seagrasses.

Description The body is smooth and limaciform, with the mid-region taller and broader and the posterior region tapering into a pointed tail. The foot is long and narrow. There are a pair of short, thick propodial tentacles curving backwards. Along the front margin of the head there are five to seven long digitiform oral processes, pointing forwards and forming an arch. The rhinophores are perfoliate (29 lamellae in a 23 mm specimen) with smooth basal regions, and behind these there is a pair of eyes inserted below unpigmented skin. There are up to eight unipinnate gills arranged in a circlet around the anus. Inserted laterally close to the gill circlet there are a pair of dorsal papillae, longer than the gills and curving backwards. The genital pore is located in the right side, about midway between the rhinophores and the gills. The ground colour is light grey in juveniles and dark grey in the adults, although the front region of the head, propodium, propodial tentacles, dorsal papillae and foot margins are pale hyaline. There is a pattern of longitudinal lines of variable length, sometimes broken into spots, which run along the whole length of the back and side. These lines are usually yellow, but can be mostly orange in some juveniles, and are often more orange laterally near the foot margins. Between the bases of the rhinophores there are a pair of short crescent-shaped lines. The median oral processes are orange while the two pairs of lateral ones are yellow. The gills and the bases of the rhinophores are light grey, with the perfoliate upper region of the rhinophores merging to dark grey. The tips of both the rhinophores and the gills are hyaline grey or white followed by a dark sub-apical region. The gill rachis has two broken lines of small yellow spots on both inner and outer sides which converge towards the tips. The branchial papillae have orange tips, followed by a sub-apical yellow band. In the adults the foot and tail margins are bordered throughout by a thin broken line of small red spots and above the propodial tentacles there is also a small irregular patch of red spots.

Discussion This sub-tropical and tropical species is reported both in the Atlantic and Mediterranean coasts of southern Spain (see Cervera *et al.*, 1988 for a review), Cape Verde Islands (as *Polycera xicoi* Ortea & Rólan, 1989) and the Angolan coast (see Vallès *et al.*, 2000 for a review). This is the westernmost report of the species in Europe and the north-westernmost one in the Atlantic ocean.

Our specimens are very similar to those originally described and illustrated by García-Gómez & Bobo (1984: 362-364 and plates I-II), who also report a maximum length of 50 mm, and they also agree with the description of Vallès *et al.* (2000: 24-25). Vallès *et al.* (2000) state that their darkest specimens from Angola have a similar colour pattern to European specimens, with great variability in the size and distribution of patches of grey, which may be completely absent from some specimens. These authors described African specimens (17 mm maximum length) as having a whitish ground colour in some specimens while in others greyish patches cover most or part of the body, but never the head region which is always white, the oral processes are yellow and the rhinophores white or yellow. Our specimens (30 mm maximum length) fit clearly the "European pattern" described by García-Gómez & Bobo (1984), which can be characterised by a darker ground colour which spreads to a greater extent over the body surface and rhinophores, with orange pigmentation in the median oral processes, but this generalisation could only be made safely when more specimens have been studied and if the "African pattern" described by Vallès *et al.* (2000) is reported from larger African specimens.

Polycera species feed on bryozoans (Picton & Morrow, 1994) and García-Gómez & Bobo (1984) collected their specimens on *Bugula neritina*, stating that *P. aurantiomarginata* probably feeds on it. This bryozoan species was abundant in the bottoms of some channels in Ria Formosa during the summer months of 2001, and on one occasion in August, several specimens of *P. aurantiomarginata* were observed crawling and feeding on large colonies on the mud bottom (see plate I, fig. C). Furthermore, our specimens were observed and collected in larger numbers from June onwards, probably in synchrony with the growth and development of their bryozoan prey.

Thecacera pennigera (Montagu, 1815)
(Plate I, figure D)

Studied material C2, 10/08/01, subtidal bed of *Z. marina*, 2-3 m depth, one specimen (22 mm - MNCN 15.05/46487) on mud bottom.

Description The body is smooth and limaciform, with the mid-region taller and broader and the posterior region tapering into a pointed tail. The foot is elongated and narrow. The propodial corners are short and pointed, curving backwards. The rhinophores are perfoliate and partially surrounded by tall sheaths, which are semi-circular in cross-section and leave the inner lateral and posterior parts of the rhinophores uncovered. These sheaths have smooth prominent borders that become taller and broader in the posterior half. There are five bipinnate gills mid-dorsally arranged in a circle around the anus, with the three larger ones anteriorly. Behind the gill circlet there is a pair of curved papillae, each one longer than the gills. The genital pore lies on the right side of the body, behind and below the rhinophore. The ground colour of the body, rhinophore sheaths, gills and papillae is hyaline light grey, with the rhinophores hyaline yellowish orange. The light grey ground colour is covered superficially by a pattern of numerous small rounded orange spots and more numerous, smaller, black spots. The tips of the papillae are hyaline white, followed by a sub-apical orange ring. The enlarged posterior half of the rhinophore sheaths has numerous minute white spots on both the inner and outer sides of the borders.

Discussion This species is considered to have a cosmopolitan distribution in temperate waters (Willan, 1976), being reported from Great Britain, the Shetland Islands, Holland, France, Sicily, north-west and south-west Spain, Madeira and the Selvagens Islands, from Cape Blanco to Angola, Cape Verde Islands, St. Helena and Ascension Islands, Brazil, South Africa, Pakistan, Japan, Australia, and New Zealand (see Dekker, 1986; Malaquias & Calado, 1997 and Vallès *et al.*, 2000 for a review). This is the most south-western report from European coasts.

This distinctive species reaches a maximum length of 30 mm (Picton & Morrow, 1994) and its unique features make identification unequivocal, e.g. the incomplete rhinophore sheaths and the orange and black spotted colour pattern. Our 22 mm specimen matches the characters described and illustrated in specimens from New Zealand (Willan, 1976: 348-349), the British Isles (Thompson, 1988: 206-207 and plate V-D; Hayward *et al.*, 1990: 716-717; Picton & Morrow, 1994:78-79) and the African Atlantic coasts (Angola) (Vallès *et al.*, 2000: 26-27). However, most of these authors describe yellow spots, in addition to the orange and black spots, which were not observed in our specimen, nor were they described in specimens from New Zealand.

Willan (1976) suggested that this species does not occur naturally over such a wide geographical area, but that this distribution results from its association with the rapidly-growing bryozoans *Bugula neritina* and *Bugula flabellata*. These occasionally settle and multiply on ship's hulls, which then transport both the nudibranch and the bryozoan around the world. Vallès *et al.* (2000), although pointing out that both the dispersal ability of this species and Willan's hypothesis have been the subject of controversy, also consider the possibility of artificial introduction when discussing the origin of their specimens from Angola. Todd (1981) states that this type of transport would result, at least initially, in distributions centred on ports, and the proximity of nearby international harbours is mentioned in the reports of Willan (1976) from New Zealand and Vallès *et al.* (2000) from Angola. Our specimen was collected inside the Ria Formosa in August, and by this time of the year the main channels of Ria Formosa are frequently used for navigation and harbouring by recreational vessels arriving from international waters. According to Willan´s (1976) hypothesis, our specimen could be an artificially introduced foreign species entering the Ria Formosa via a ship's hull.

FAMILY DORIDIDAE Rafinesque, 1815
Doris sticta (Iredale & O'Donoghue, 1923)
(Plate I, figure E)

Studied material C6, 22/11/99, 1 m depth, one specimen (6 mm - MNCN 15.05/46483) on sandy mud bottom with benthic organisms.

Description The body is elongated and broad. The dorsum is covered with large spicular tubercles of irregular size and length, which are evenly distributed and interconnected by a network of prominent narrow ridges. The propodium has a transverse groove, and the oral tentacles are short and grooved. The rhinophores are perfoliate (7 lamellae in our 6 mm specimen). There are six bipinnate gills arranged in a circle around the anus. The basal regions of the rhinophores and gills are surrounded by large prominent tubercles. Numerous spicules were observed on both the dorsal and ventral sides of the mantle, many of them clearly puncturing the body. The ground colour of the body, rhinophores and gills is yellowish orange, with the propodium and foot pale yellow. The tips of the dorsal tubercles are brown, forming a regular pattern of dark points over the light ground colour of the dorsum. The ridges interconnecting the dorsal tubercles are light grey. There are also numerous superficial brown spots on the gills and on the sides of the foot.

Discussion The species is reported from the Atlantic in the British Isles (Thompson, 1988; Picton & Morrow, 1994), along the coasts of Northern Brittany to Morocco (Thompson, 1988) and in the north-eastern Spanish coasts (see Cervera *et al.*, 1988 for a review, as *Doris maculata* Garstang, 1895). Mediterranean reports include the Gibraltar Strait, the north-eastern Spanish coasts (Cervera *et al.*, 1988 for a review) and the southern French coasts (Thompson, 1988). This is the most south-western report in European coasts.

Our 6 mm specimen generally matches with the specimens from the British Isles described and illustrated by Thompson (1988: 222-223) and Picton & Morrow (1994: 82-83). This is an uncommon and distinctive species that may reach a maximum length of 45 mm, and although it probably feeds on sponges, its dietary preferences remain unknown (Picton & Morrow, 1994).

FAMILY DISCODORIDIDAE Bergh, 1891
Discodoris atromaculata (Bergh, 1880)
(Plate I, figure F)

Studied material A4, 14/05/99, 6 m depth, one specimen (48 mm - LZM/USC 05140599) on the sponge *Petrosia ficiformis*, on rocky bottom near the opening of a small cave; B1, 23/06/01, 20 m depth, one specimen (35 mm - MNCN 15.05/46485) on bottom rocks.

Description The body is elongated and slightly rounded. The mantle is covered with numerous semi-spherical spicular tubercles of varying size, very close together. The mantle margins are slightly irregular with notches and are also covered with tubercles. The foot is broad, and the propodium is notched and grooved transverse. The oral tentacles are short and thick. The rhinophores are perfoliate. There are seven unipinnate gills arranged in a circle around the anus. There are numerous spicules in both the dorsal and ventral surfaces of the body. The ground colour of the whole body, foot, rhinophores and gills is opaque white. The white dorsum is covered by a superficial pattern of rounded or irregular brown spots of variable size bordered by a thin black line and with some small white spots in the brown; the larger spots are mainly in the centre of the dorsum and the smaller ones close to the mantle margin.

Discussion This species is reported from the Mediterranean in the North Aegean Sea (see Koutsoubas & Koukouras, 1993), Ligurian sea (Cattaneo-Vietti *et al.*, 1993), Balearic Islands and along the coasts extending from the north-eastern Spanish coasts to Gibraltar Strait (see Cervera *et al.*, 1988 for a review). Atlantic reports include the north-eastern Spanish coasts, Canary Islands (Cervera *et al.*, 1988 for a review) and the archipelagos of Madeira (Wirtz, 1994; 1999) and the Azores (see Malaquias, 2001 for a review). The present reports are the most south-western ones from European coasts.

This distinctive and well-known species has been the subject of several morphological, anatomical, biochemical and behavioural studies (see Cattaneo-Vietti *et al.*, 1993 and Ávila, 1996) and can be easily identified by its unique dorsal pattern of brown spots on a white mantle, as illustrated in Ávila (1996: 152). This species is also referred to in the literature as *Peltodoris atromaculata* (e.g. Perrone, 1989; Ávila, 1996). We use the name

Discodoris atromaculata following Cervera *et al.* (1988) and others, although according to Ávila (1996) there are morphological differences (in the jaws, for example) that define generic separation.

Our specimen from Arrábida was found on the sponge *Petrosia ficiformes*, on which this species usually feeds (see Cattaneo-Vietti *et al.*, 1993 and Ávila, 1996) and upon which it is very sedentary (Ávila, 1996). According to Cattaneo-Vietti *et al.* (1993), although the trophic relationship between *D. atromaculata* and *P. ficiformes* has been confirmed and is considered to be one of the best examples of monophagy among nudibranchs, it occasionally feeds on other species. These authors collected one specimen on the sponge *Reniera fulva* and the presence of spicules from this sponge in its gut proves feeding upon it. Megina *et al.* (2002) suggest that *D. atromaculata* may be an obligate specialist with an oligophagous diet of two prey sponges.

FAMILY DENDRODORIDIDAE O'Donoghue, 1924
Dendrodoris herytra Valdés & Ortea *in* Valdés *et al.*, 1996
(Plate II, figure G)

Studied material B1, 23/06/01, 8-10 m depth, one specimen (25 mm - MNCN 15.05/46486) under rocks.

Description The body is elongated and broad. The mantle is smooth with long and highly undulating margins with radiating striations. The foot is elongated and broad, with slightly undulating borders. The oral tentacles form a pair of short ridges. The rhinophores are perfoliate (18-19 lamellae in our 25 mm specimen) with smooth bases, with the perfoliate region inclined and pointing backwards. There are six small arborescent tripinnate gills arranged in a semi-circle closed posteriorly by the anus. The ground colour of the body, foot, rhinophores and gills is pale pinkish red, with the mantle margins and gills more hyaline. Spread over the surface of the dorsum lies an irregular pattern of rounded or oval red spots, some of which are fused. The tips of both rhinophores and gills are white and there are numerous small white spots on the bases of the gill rachis.

Discussion This recently described species is reported from the Mediterranean in the Alboran sea and from the Atlantic on the northern Spanish coasts, Canary Islands and the archipelagos of Madeira and the Azores, and probably also on the French coasts (Biscay bay) and Gibraltar Strait (see Valdés *et al.*, 1996 for a review, and Malaquias, 2001 for a review of the Azorean reports). The distribution map provided by Valdés *et al.* (1996: 22, fig.12-B) shows a geographical range that also includes both the Moroccan and Portuguese coasts, but since we could not find any justification or cited literature supporting this information, we consider our finding to be the first report from the Portuguese coast, being also the most south-western report from European coasts.

The dorsal colour pattern of Atlantic *Dendrodoris* species is very variable. Juveniles and adults of *D. herytra* can usually be recognised by the red ground colour, however the species shows considerable intra-specific variation in the dorsal colour pattern, with some specimens having a yellowish ground colour covered by red or pale green spots, while specimens described from the Canary Islands and the Azores have a grey ground colour covered with black spots (Valdés *et al.*, 1996). The colour pattern of our 25 mm specimen fits the usual colour pattern described and illustrated by Valdés *et al.* (1996: 4, 25), who also reported a maximum length of 32 mm. These features also allow separation from other eastern Atlantic species. Specimens of *D. limbata* and *D. grandiflora* have a highly variable ground colour (yellow, grey, dark brown or black in *D. limbata*; yellow, cream, grey, pale green, pale brown and light red in *D. grandiflora*) with brown or black spots dorsally, and tips of the rhinophores and the gills white (Valdés *et al.*, 1996), but they always lack red spots. Specimens of *D. angolensis* may have an orange ground colour with orange or red spots dorsally, but the tips of the rhinophores are red and there is a thin red line on the edges of the gill and mantle margins. Juveniles of *D. senegalensis* are uniformly red, while adults may have an orange ground colour, and have the tips of the rhinophores and gills white, but they lack red spots dorsally. Mature specimens of *D. guineana* from Equatorial Guinea have a red ground colour, but there are no spots at all (Valdés *et al.*, 1996). Furthermore, these three latter species have been reported so far only on the Mauritanian zoogeographical region, from sub-tropical and tropical waters between the latitudes 20° N and 15° S (see Valdés *et al.*, 1996, p. 8, fig. 4-C, and p. 22, fig. 12-A and 12-C) and are unlikely to occur on temperate southern Portuguese waters.

No data are currently available on the ecology and food preference of this species. *Dendrodoris* species feed on sponges (Picton & Morrow, 1994). Our specimen was found under bottom rocks, as do other species of *Dendrodoris* species; e.g. *D. limbata* is frequently found under submerged or exposed rocks on the southern Portuguese coasts (personal observation).

SUBORDER DENDRONOTACEA Odhner, 1934
FAMILY HANCOCKIIDAE MacFarland, 1923
Hancockia uncinata (Hesse, 1872)
(Plate II, figures H, I)

Studied material A3, 12/05/99, sand bottom with rocks covered by large amounts of hydrozoans and the algae *Chondrus crispus* and *Sargassum* sp., 9 m depth, 2 specimens (11 mm max. length - LZM/USC 01120599); B2, 23/06/01, one specimen (6 mm - MNCN 15.05/46484) on exposed intertidal rocks covered by algae.

Description The body is smooth, long and slender, terminating in a short rounded tail. The foot is long and narrow. Antero-laterally on the head corners there are a pair of flap-like oral tentacles, each with three or four short digitiform processes, with the median one the longest. The rhinophores are short with longitudinal striations and prominent swollen tips; they are surrounded for two-thirds of their length by tall narrow sheaths with scalloped margins. There are up to four pairs of cerata in a 6mm specimen, inserted dorso-laterally. Each ceras consists of a circlet of up to ten tubercular processes with small protuberant surface papillae, and the number of these processes per group decreases from the anterior to the posterior region. The ground colour of the body, oral tentacles, rhinophore sheaths, and cerata, is reddish-pink. The rhinophores are hyaline white covered by numerous superficial white spots, which are also present on the bases and aperture margins of the rhinophore sheaths and around the bases of the cerata. There are also small light pink and light green spots on the external side of the rhinophore sheaths and on the inner sides of the cerata.

Discussion This is an anphiatlantic species with a geographical distribution that includes the Eastern Boreal, Lusitanean, Mediterranean, West African and Caribbean geographical areas (Templado *et al.*, 1987) and it is considered to be able to cross the Atlantic frequently on floating *Sargassum* at all stages of its life cycle (Edmunds, 1977). It is reported from the Mediterranean in Ceuta and all along the southern coasts of Spain (see Cervera *et al.*, 1988 and Moreno & Templado, 1998 for a review), France and Naples (Picton & Morrow, 1994) and in the north Aegean Sea (Ledoyer, 1966). Atlantic reports include the British Isles (Thompson, 1988; Picton & Morrow, 1994) and the northern coasts of Spain (see Cervera *et al.*, 1988 for a review). The present reports are the most south-western ones from European coasts.

Our specimens agree with the characters described and illustrated in specimens from the British Isles (Thompson, 1988: 122-123; Picton & Morrow, 1994: 36-37). This is a rare species that reaches a maximum length of 14 mm (Thompson, 1988; Picton & Morrow, 1994). It lives on floating *Sargassum* but is also frequent in benthic shallow water with algae in temperate or warm waters (Templado *et al.*, 1987), and has been reported on fields of *Posidonia oceanica* (Moreno & Templado, 1998). Its diet includes the hydrozoan *Clytia haemisferica*, which grows on other hydrozoans or on algae (Picton & Morrow, 1994), and probably the hydrozoans *Tubularia indivisa, T. larynx* and *Campanularia* sp. (Todd, 1981), with Urgorri & Besteiro (1984) reporting *Campanularia johnstoni* as prey species in north-western Spain. Our data agree with this, since our specimens from Arrábida were collected on rocky bottoms with *Sargassum* and many hydrozoans, and the specimen from Sagres was collected on intertidal rocky substrate covered with algae which were probably colonised also by its hydrozoan prey. Recently we found some specimens and egg masses on the red alga *Plocamium cartilagineum* (see plate II, figure I), on which the specimens are highly cryptic as a result of their red coloration.

FAMILY DOTOIDAE Gray, 1853
Doto millbayana Lemche, 1976
(Plate II, figure J)

Studied material A2, 11/05/99, 10 m depth, four specimens (8, 5 mm max. length - LZM/USC 15110599) on a hydrozoan growing over *Codium tomentosum.*

Description The body is smooth, long and slender, with a rounded tail. The foot is long and narrow. The propodial corners extend as a pair of short rounded processes pointing laterally. The rhinophores are smooth and long, and are surrounded basally by tall sheaths with enlarged aperture margins, which are slightly taller and more prominent anteriorly. The cerata are irregular in size, and with up to five superimposed circles of prominent conical or rounded tubercles irregularly distributed along their length, and a larger one at the tip. There are up to six pairs of cerata inserted dorso-laterally, with the last pair never reaching the tip of the tail when bended. The ground colour of the body is hyaline yellowish white, covered by a superficial pattern of irregular reddish brown spots spread over the dorsum, head, sides and rhinophore sheaths, with a few spots also present on the cerata. The rhinophores are hyaline white covered with numerous superficial opaque white spots, which also occur densely on the aperture margins of the rhinophore sheaths, and on the tips of the propodial processes. The tips of the ceratal tubercles have superficial rounded or irregular dark spots and also numerous internal white granules.

Discussion This species is reported only from the Atlantic in the British Isles and Shetland Islands (Thompson 1988; Hayward *et al.*, 1990; Picton & Morrow, 1994) and in the northeastern and southwestern coasts of Spain (see Cervera *et al.*, 1988 for a review). This is the most western report in Europe and the most south-western one from the Atlantic coasts.

Our specimens agree with the characters described and illustrated in specimens from the northern Spanish coasts (Ortea & Urgorri, 1978: 76-77, 85) and the British Isles (Thompson, 1988: 148-149; Hayward *et al.*, 1990: 711-712; Picton & Morrow, 1994: 48-49). This species is mentioned as uncommon and reaching a maximum length of 14 mm (Thompson, 1988; Hayward *et al.*, 1990). It is a specialist feeder on the calyptoblast hydrozoan *Plumularia setacea*, that grows over other larger hydroids like *Nemertesia antennina* and *N. ramosa* (Picton & Morrow, 1994). *N. ramosa* can also be eaten occasionally

(Todd, 1981; Hayward *et al.*, 1990), and Ortea & Urgorri (1978) found adults together with egg masses on *Aglaophenia* sp. We cannot confirm this information or add new data since the hydrozoan on which our specimens were found was not identified.

SUBORDER AEOLIDACEA Odhner, 1934
Family Facelinidae Bergh, 1889
Favorinus blianus Lemche & Thompson, 1974
(Plate II, figure K)

Studied material A1, 11/07/00, 11 m depth, two specimens (9 mm max. length IPM - 01110700) on rocky bottom substrate.

Description The body is smooth and limaciform, with the posterior region tapering into a long pointed tail. The foot is long and narrow. The propodial tentacles are long, pointed and curving backwards, and there is a pair of long oral tentacles. The rhinophores are smooth with three large bulbs above the bases followed by a long pointed tip. Near the bases of the rhinophores a pair of small black eyes can be seen. The cerata are long and slender, of variable size, and arranged dorso-laterally in dense rows, with the last row inserted well in front of the tip of the tail. The ground colour of the body and rhinophores is hyaline pale yellow, with a superficial white pigmentation on the tips of the propodial processes, rhinophores and cerata. There is a continuous white line extending along each oral tentacle. These lines unite in the head region, and proceed from there to the posterior region as a discontinuous median white line which extends to the tip of the tail. The surface of the cerata also has numerous white spots. The branches of the digestive gland are light yellowish brown.

Discussion This Atlantic species is reported from the British Isles, Norway and Denmark (Thompson, 1988; Picton & Morrow, 1994) and from the north-western Spanish coast (see Cervera *et al.*, 1988 for a review). This is the most south-western report from European coasts and from the Atlantic Ocean.

Our specimens agree with the characters described and illustrated in specimens from the British Isles (Thompson, 1988: 324-325 and plate VIII-A; Hayward *et al.*, 1990: 722, 725; Picton & Morrow, 1994: 126-127). This distinctive species can be easily recognised by the large body and the three bulbs on the rhinophores, however not much is known about its biology. It reaches a maximum length of 30 mm and is known to feed on the hydrozoan *Tubularia larynx* and on the eggs of other nudibranchs (Thompson, 1988; Hayward *et al.*, 1990), so it is likely to be found wherever other nudibranchs are abundant (Picton & Morrow, 1994).

FAMILY EUBRANCHIDAE Odhner, 1934
Eubranchus doriae (Trinchese, 1874)
(Plate II, figure L)

Studied Material A2, 11/05/99, 10 m depth, one specimen (9 mm - LZM/USC 14110599) on a hydrozoan.

Description The body is smooth and limaciform, with the posterior region tapering into a pointed tail. The foot is long and narrow. The propodium has a pair of short and pointed tentacles. The rhinophores and oral tentacles are smooth and about the same length, with the oral tentacles being more slender. There are six rows of cerata in our 9 mm specimen, with up to four cerata of irregular size per row. The anus lies behind the heart on the right side of the dorsum. The ground colour of the body, oral tentacles and cerata is hyaline white, covered with brown patches on the head, rhinophores and interceratal regions, which become lighter and sparse mid-dorsally. There are numerous superficial white, brown and olive-green spots spread over the surface of the dorsum and head, oral tentacles, rhinophores and cerata, with the brown and olive-green ones more numerous on the cerata and interceratal regions and the white ones in higher numbers on the oral tentacles, rhinophores and head. The tips of the oral tentacles, rhinophores and cerata are white. The digestive gland shows a pale whitish yellow colour.

Discussion This species is reported from the Atlantic in the British Isles (Thompson, 1988; Picton and Morrow, 1994), and the French coasts (see Edmunds & Kress, 1969 for a review). Mediterranean reports include Italy and southern France (see Edmunds & Kress, 1969 for a review). This is the first report for the Iberian Peninsula and the most south-western one in both the European coasts and the Atlantic Ocean.

Our specimen matches the characters described and illustrated in specimens from the Mediterranean French coasts (Edmunds & Kress, 1969: 903) and the British Isles (Thompson, 1988: 290-291; Picton and Morrow, 1994: 114-115). The species reaches a maximum length of 12 mm and feeds on the hydrozoan *Kirchenpaueria similis* in the British Isles (Picton and Morrow, 1994), being also known to feed on *Plumularia setacea* (Thompson, 1988). Specimens from the French Atlantic coast were found on *K. pinnata* and larvae were observed metamorphosing on this hydrozoan species but not on several others (Tardy, 1962). Our specimen was found on an unidentified hydrozoan, together with some specimens of *Eubranchus vitattus*. This latter species is also reported to feed also on *K. pinnata* (Picton and Morrow, 1994) but also on *Antenella catharina* and probably on *Clytia johnstoni* and *Obelia geniculata* (Todd, 1981).

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We would like to thank all of our friends and colleagues from the Universidade do Algarve, who kindly helped by providing specimens for study. Special thanks go to Prof. Martin Sprung (Universidade do Algarve, died in the same car accident as Cesar Gavaia) for his support and help during the work and to Ana Ruel for her help with the English version of the manuscript. We also thank the improving suggestions made by an anonymous referee. We are also grateful to the Parque Natural da Ria Formosa, to the Parque Natural do Sudoeste Alentejano and Costa Vicentina and to the Parque Natural da Arrabida, for all the facilities provided. This work was partially supported by the projects Acções Integradas Luso-Espanholas/Acciones Integradas Hispano-Portuguesas (E-13/97 / HP1996-0084 and E-51/98 / HP1997-0016), and Fauna Iberica project REN2001-1956-C17-02/GLO (MCYT, Spain).

This work intended to be part of the BSc. thesis of the first author, which due to the tragic circumstances was not concluded.

OBITUARY NOTE

Cesar Gavaia tragically died on the 3rd of July 2003 from injuries sustained in a car accident, which occurred while returning from a fieldwork excursion. Cesar was a student of Marine Biology at the University of the Algarve, where he was engaged in completing his first degree final thesis on the opisthobranchs of Portugal. This paper is part of his legacy and a valuable contribution to the understanding of the diversity and biology of these molluscs.

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PLEUROPLOCA GRANULILABRIS, A NEW WARM-TEMPERATE FASCIOLARIID GASTROPOD FROM BRAZIL

GEERAT J. VERMEIJ[1] & MARTIN AVERY SNYDER[2]

Abstract *The new species* Pleuroploca granulilabris, *recorded in southern Brazil from off Rio de Janeiro State to Santa Catarina State, is most similar in shell characters to species from temperate Australia, the tropical Indo-West Pacific, and the early Miocene to Recent of the eastern Atlantic.*

Key words *Mollusca, gastropod, Fasciolariidae,* Pleuroploca, *new species, Brazil.*

INTRODUCTION

The Brazilian fauna is a biogeographically fascinating mixture dominated by western Atlantic elements and with additional representatives of clades otherwise known only from the eastern Atlantic, Indo-West Pacific, and temperate southern hemisphere. We are far from a complete understanding of the complexities involved because much of the basic descriptive work of characterizing new taxa and determining range limits remains to be done. The present paper is a modest contribution to this end. We describe the new warm-temperate Brazilian fasciolariid gastropod *Pleuroploca granulilabris*, and point out its affinities with species in temperate Australia, the tropical Indo-West Pacific, and eastern Atlantic. As further deep-water fishing operations are carried out off the coast of Brazil we can expect the discovery of more new species from this area.

Abbreviations for museums and collections are as follows:

ANSP	Academy of Natural Sciences of Philadelphia, Pennsylvania, U.S.A.
MZSP	Museu de Zoologia da Universidade de São Paulo
SC	Snyder Collection, Villanova, Pennsylvania, U.S.A.

SYSTEMATIC DESCRIPTION

FACIOLARIDAE
SUBFAMILY FASCIOLARIINAE Gray, 1853
Genus *Pleuroploca* Fischer, 1884

Pleuroploca granulilabris, n.sp.
Figs. 1-6

Holotype Collected off Rio de Janeiro, Brazil, at 70 m by shrimp boats, 1990. MZSP 36357.

Paratypes Paratype 1, dived 7 miles east of Ilha de Santa Catarina, Brazil, 2003, ANSP 410706; paratype 2, trawled at 80-100 m off Macaé, Brazil, 2002, SC; paratype 3, off Rio de Janeiro, Brazil, 1994, SC.

Shell Measurements Holotype: length 62.8 mm, diameter 31.2 mm, aperture height 20.7

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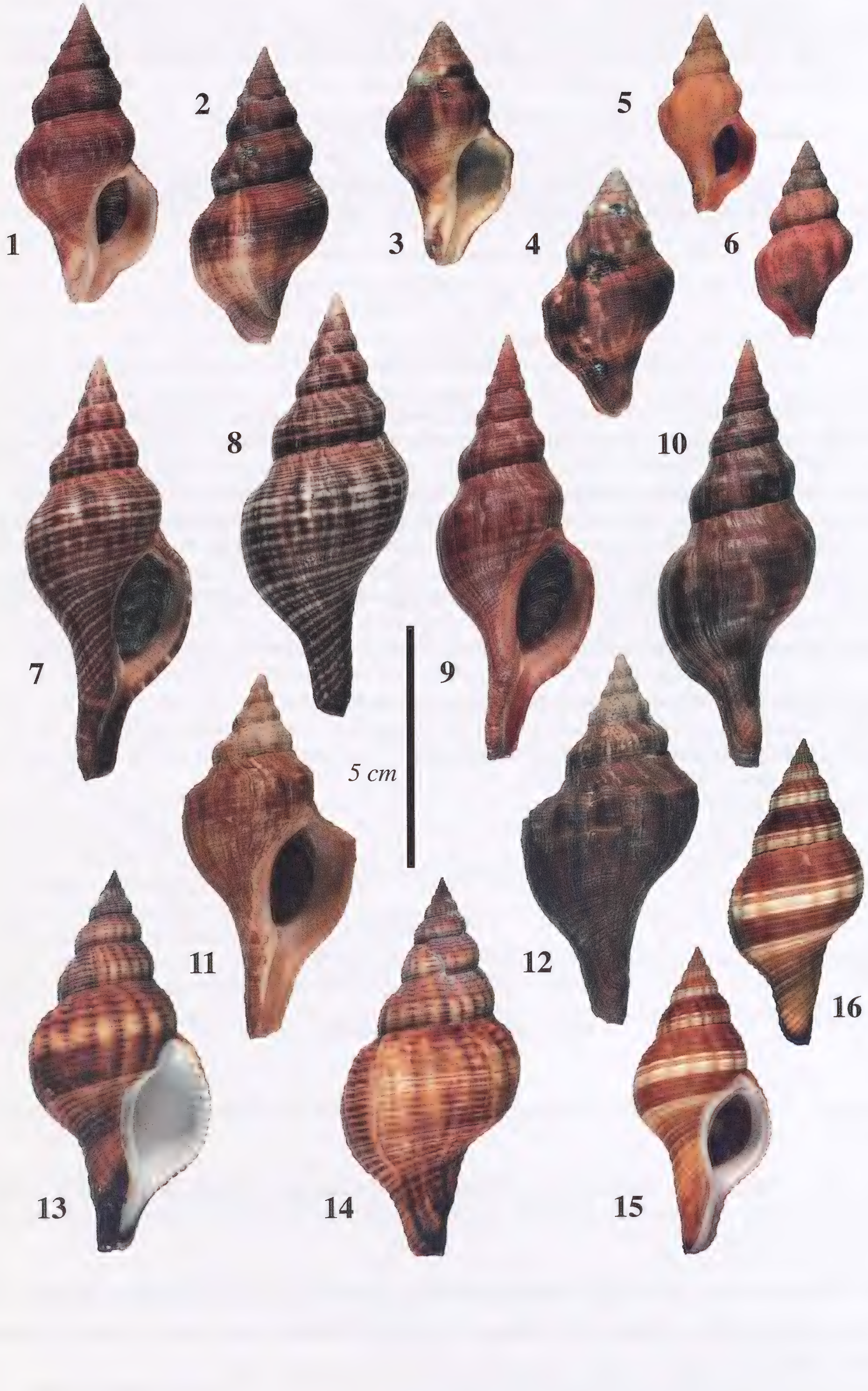
[1] Department of Geology, University of California at Davis, One Shields Avenue, Davis, CA 95616, vermeij@geology.ucdavis.edu

[2] Department of Malacology, Academy of Natural Sciences of Philadelphia 19th and Benjamin Franklin Parkway, Philadelphia, PA 19103, DrMartinSnyder@earthlink.net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mm, aperture width 11.8 mm. Paratype 1: length 53.1 mm, paratype 2, length 42.7 mm, paratype 3, length 71.5 mm.

Other material examined 12 other specimens, collected from the same locales as the type material (all SC).

Type Locality Off Rio de Janeiro, Rio de Janeiro State, Brazil.

Diagnosis Relatively small *Pleuroploca* with low spire, short siphonal canal, low to obsolete axial ribs, deeply recessed beaded lirae, and keeled adapical edge of siphonal canal.

Description Shell fusiform, basally constricted, relatively small for genus (maximum height 71.5 mm), thick; protoconch paucispiral; teleoconch consisting of up to eight moderately convex whorls separated by appressed sutures; spire whorls with obtuse, sharply rounded shoulder angulation, two spiral cords above and four cords below angulation; penultimate and last whorls with eight spiral threads above spiral angulation, the uppermost three of which are finest; penultimate whorl with eight cords at and below shoulder angulation; last whorl of large shells with about 30 spiral cords and threads, of which about 12 are situated below the central sector of the whorl; larger cords tend to alternate with finer threads; axial sculpture of spire whorls consisting of ten to 14 low, rounded ribs per whorl, extending from shoulder angulation to lower suture; ribs becoming obsolete or disappearing on last one or two whorls; surface of shell roughened by growth lines; aperture ovate-elongate; outer lip thin, crenulated at edge, with broad, shallow abapical and adapical sinuses and a convex central sector; inner side of outer lip marked by 23 beaded (interrupted) lirae extending from lip's edge to well within aperture; inner lip adherent except for very narrow umbilical slit in some specimens; columella with two or rarely three low folds adapical to fold marking entrance to siphonal canal; adapical end of inner lip with low but distinct parietal ridge; siphonal fasciole rounded; adapical free margin of siphonal notch keeled; color brown to brownish orange.

Derivation of name Combination of Latin *granula* (little grain) and *labrum* (specifically the shell's outer lip), adjectival form referring to the beaded lirae on the inner side of the outer lip.

Distribution Off Macaé, Rio de Janeiro State, to Ihla de Santa Catarina, Santa Catarina State, Brazil, 7 to 200 m.

Comparisons All of our material was purchased from dealers in both Brazil and Argentina, and was collected as a byproduct of local commercial fishing operations. Collectors and dealers have until now confused this new species with *Leucozonia nassa*

Figs 1, 2 Holotype shell of *Pleuroploca granulilabris*, n. sp. **Figs 3, 4** Paratype 1 of *Pleuroploca granulilabris*, n. sp. **Figs 5, 6** Paratype 2 of *Pleuroploca granulilabris*, n. sp. **Figs 7, 8** *Pleuroploca filamentosa* (Röding, 1798), trawled in the Palk Strait off Jaffna, north Sri Lanka, collected 2000, SC, 78.3 mm **Figs 9, 10** *Pleuroploca glabra* (Dunker, 1882), 40-80 m off Kii Straits, Japan, collected 2001, SC, 90.8 mm **Figs 11, 12** *Pleuroploca australasia* (Perry, 1811), off Flinders Island, Bass Strait, southeast Australia, collected 1986, SC, 78.3 mm **Figs 13, 14** *Pleuroploca buxea* (Reeve, 1847), trawled at 45 m by shrimpers, São Vicente Channel, Cape Verde Islands, collected 2001, SC, 80.3 mm **Figs 15, 16** *Pleuroploca buxea* (Reeve, 1847), trawled 40-45 m, São Vicente Channel, Cape Verde Islands, collected 2002, SC, 64.9 mm

(Gmelin, 1791), not suspecting a genus not previously known from this area to have a Recent representative. Both species have a broadly fusiform shell with variably developed axial sculpture and granular lirae on the inner side of the outer lip. The genus *Leucozonia* has been definitively studied and characterized (Vermeij and Snyder, 2002) and there is little doubt that this species must be assigned elsewhere. In *Pleuroploca granulilabris* there is no labral tooth and corresponding enlarged cord separating the convex sector of the last whorl from the base, as there is in most specimens of *L. nassa* and in other typical species of *Leucozonia.* There are 2-3 columellar folds as opposed to 3-4 in *Leucozonia.* Moreover, the lirae extend from the edge of the outer lip into the aperture in *P. granulilabris* and in other species of *Pleuroploca*, whereas in *Leucozonia* they begin at some distance from the edge of the lip. The new Brazilian species *Pleuroploca granulilabris* forms part of a complex of fossil and living species that is otherwise known only from the eastern Atlantic, Indo-West Pacific, and temperate Australia. Other species in this complex include *Pyrula australasia* Perry, 1811 (Recent, temperate Australia); *Fusus buxeus* Reeve, 1847 (Recent, Cape Verde Islands); *Fusus filamentosus* Röding, 1798 (Recent, tropical Indo-West Pacific); *Fasciolaria glabra* Dunker, 1882 (Recent, Japan); *Fasciolaria michelottiana* Grateloup, 1847 (early Miocene, France; see Lozouet *et al.*, 2001, for discussion and synonymy); and *Fasciolaria tarbelliana* Grateloup, 1847 (Late Miocene, southern Europe, including Early Miocene and Middle Miocene forerunners). We illustrate these four other related Recent species. All these species are characterized by fine but distinct spiral cords distributed over the whole shell, a crenulated outer lip with a convex central sector, axial sculpture consisting of low rounded ribs sometimes forming nodes at the shoulder angulation, and beaded or discontinuous ridges (lirae) on the inner side of the outer lip. All the species appear to be variable in the expression of axial sculpture, which ranges from distinct ribs throughout ontogeny to a pattern in which ribs are obsolete on the last two whorls or sometimes all of the teleoconch whorls.

At a maximum height of 71.5 mm, *P. granulilabris* is the smallest of these species of *Pleuroploca* with beaded lirae. It is perhaps most similar to the temperate Australian *P. australasia* (figures 11, 12) (see Wilson, 1994, for discussion of variation and synonymy). *P. granulilabris* (figures 7, 8) differs from *P. australasia* by having more numerous spiral cords and threads, more distinctly granular as compared to discontinuous lirae, and an adapically keeled siphonal canal. The Indo-Pacific *P. filamentosa* differs from *P. granulilabris* by attaining a larger size (often well over 100 mm), by having more numerous granular lirae (up to 50 as compared to 23 in *P. granulilabris*), by generally being more nodose at the shoulder angulation, and by having three instead of two columellar folds. In *P. filamentosa*, the adapical-most columellar fold is, however, very weak. The adapical edge of the siphonal canal is keeled in *P. granulilabris* but not in *P. filamentosa*. The spire is higher and the siphonal canal is longer in *P. filamentosa* than in *P. granulilabris*. *P. granulilabris* may also be compared to the similar Japanese species *P. glabra* (figures 9, 10).

Another similar Recent species is *P. buxea* (figures, 13-16) from the Cape Verde Islands. Besides reaching a larger size, the Cape Verde species lacks shoulder nodes, which are present in some specimens of *P. granulilabris*.

The oldest known species in this group is the Early Miocene European *P. michelottiana*. As understood by Lozouet *et al.* (2001), this is a variable species, which differs from the Recent species by having fewer, stronger axial ribs and three to four columellar folds. *P. tarbelliana*, another but later Miocene species, has still stronger axial ribs, which form spinose nodes on the shoulder angulation.

Pleuroploca granulilabris is geographically isolated in subtropical to warm-temperate Brazil. Its somewhat deep water habitat is fairly typical of the other Recent *Pleuroplocas* we have discussed, except for the shallow water *P. filamentosa*. How and when its ancestors got there remains unknown. One possibility is that a propagule of the temperate *P. australasia* or its ancestor was able to extend its range through larval dispersal to the southwestern Atlantic. The tail-end of the distribution of *P. filamentosa* occurs on the offshore reefs of southern Natal, South Africa, on a Pleistocene dune ridge parallel to the coast at about 20-70 m (private communication, Richard Kilburn). This also suggests possible propagation into the southwestern Atlantic.

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TAXONOMICAL CLARIFICATION OF *HELIX SEMIPICTA* HIDALGO, 1870 (GASTROPODA: PULMONATA: HYGROMIIDAE)

ALBERTO MARTÍNEZ-ORTÍ[1] & Mª TERESA APARICIO[2]

Abstract *With the aim of clarifying the taxonomical status of* Helix semipicta *Hidalgo, 1870 its* locus typicus *has been sampled intensively and the specimens collected have been compared with the syntypes deposited in the Museo Nacional de Ciencias Naturales in Madrid. Furthermore the shell and the reproductive system of* Helix semipicta *have been compared to specimens of* Helicella cistorum *(Morelet, 1845), the most similar Iberian hygromide, and the conclusion that* Helix semipicta *Hidalgo, 1870 is a junior synonym of* Helix cistorum *Morelet, 1845, has been made, further amplifying the known distribution of this species.*

Key words Helix semipicta, Helicella cistorum, *Hygromiidae, synonymy, Iberian Peninsula.*

INTRODUCTION

Helix semipicta was described by Hidalgo in 1870 and whose *locus typicus* is "Alcaraz" (Albacete, Spain). Puente (1994) situates it in the group of Iberian species *incertae sedis* and Templado, Baratech, Calvo, Villena & Aparicio (1993) include it in the Familia Hygromiidae given the morphology of the shell, upon not knowing its anatomy.

The authors have intensively sampled the type locality collecting specimens and have studied the syntypes deposited in the Museo Nacional de Ciencias Naturales in Madrid (MNCN) and material from other collections, with the objective of clarifying its taxonomical status. The Museé National d'Histoire Naturelle in Paris possesses deposited one more syntype (Fisher-Piette, 1950; Templado et al., 1993). From those syntypes the lectotype of *Helix semipicta* has been selected. The study of the reproductive system of the specimens collected in the *locus typicus* has been carried out and it has been compared with specimens of *Helix cistorum* Morelet, 1845 (currently *Helicella cistorum*), an endemic species of the Iberian Peninsula and the closest within the Familia Hygromiidae, which proceed from the Ortiz de Zárate and Ana I. Puente collections.

MATERIAL AND METHODS

Given that the name "Alcaraz" is applied as much to a city as to a mountain range, both in the province of Albacete, the whole mountain range of Alcaraz just as, more intensively, the surroundings of the city with the same name, have been sampled. Of the 27 points sampled *Helix semipicta* has only been found in the "Cerro de los Pizorrosos del Aljibe, road from Reolid to Salobre, km 2" (UTM: 30SWH368728). The specimens (one live and 14 shells) have been localised at the base of the thicket vegetation in a solid of quartzite at 1000 m altitude, and are found deposited in the Museu Valencià d'Història Natural in Valencia (MVHN, nº 801) (Fig. 1a).

In turn the syntypes of *Helix semipicta* from the Hidalgo collection have been revised, deposited in the Museo Nacional de Ciencias Naturales in Madrid in two lots, nº 15.05/

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[1]Museu Valencià d'Història Natural. Passeig de la Petxina, 15. 46008 Valencia (Spain). alberto.martinez@uv.es
[2]Museo Nacional de Ciencias Naturales. C.S.I.C. c/ José Gutiérrez Abascal, 2. 28006 Madrid (Spain). mcnta2a@mncn.csic.es

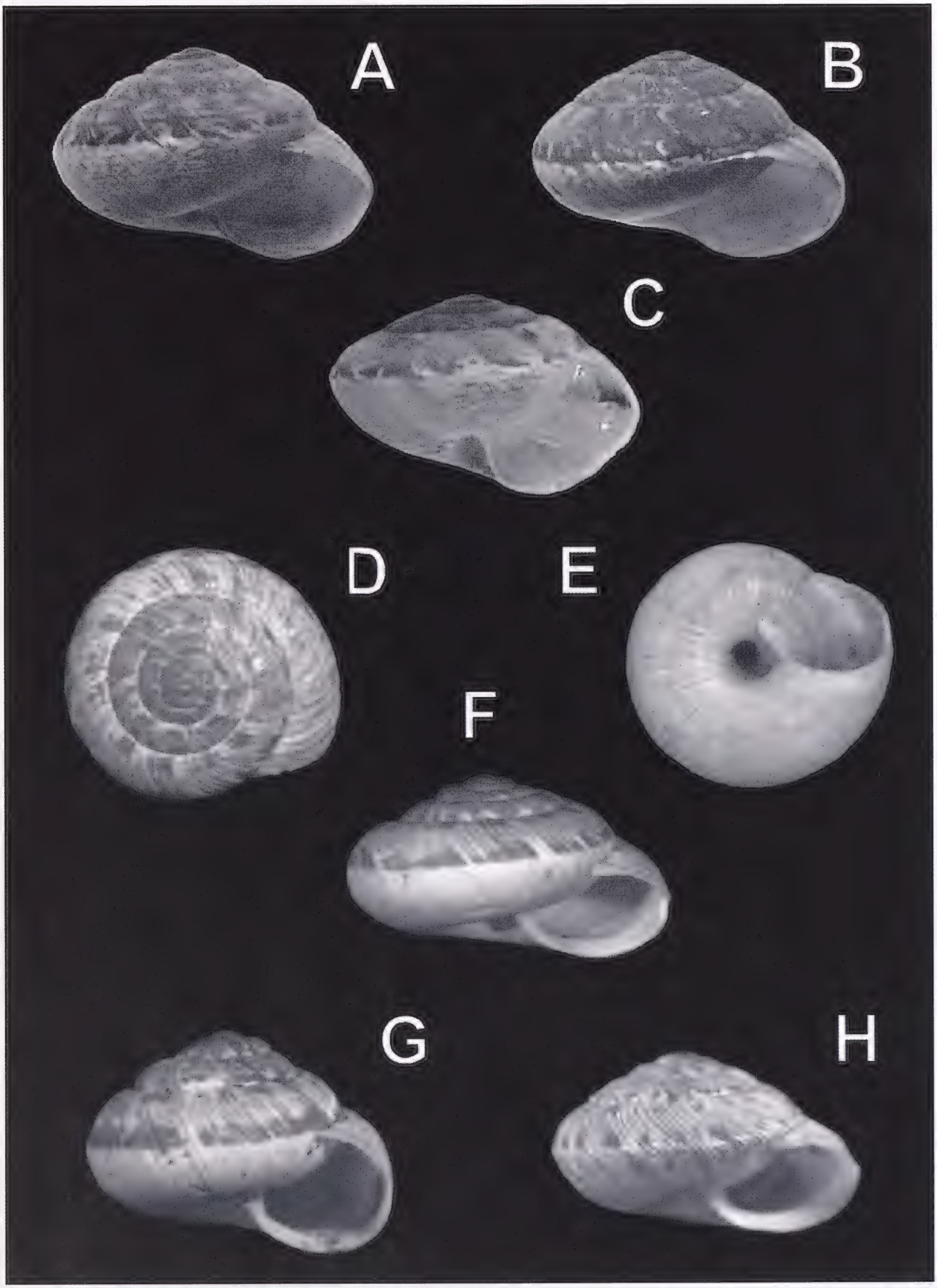

Fig. 1 **A** *Helicella cistorum* (Morelet, 1845) collected at the type locality of *Helix semipicta* (MVHN, n°801), 11.1 mm diameter. **B** *Helicella cistorum* (Morelet, 1845). A. I. Puente leg. (MVHN, n°802), 10.7 mm diameter. **C** *Helicella cistorum* (Morelet, 1845). Ortiz de Zárate leg. Siro de Fez col. (MVHN, n°640), 9.9 mm diameter. The presence of the epiphragm can still be observed in the opening. **D-F** Lectotype of *Helix semipicta* Hidalgo, 1870 (MNCN, n° 15.05/2756), 8.90 mm diameter. **G** Paralectotype of *Helix semipicta* (MNCN, n° 15.05/2756), 8.92 mm diameter. **H** Paralectotype of *Helix semipicta* (MNCN, n° 15.05/2756), 8.73 mm diameter.

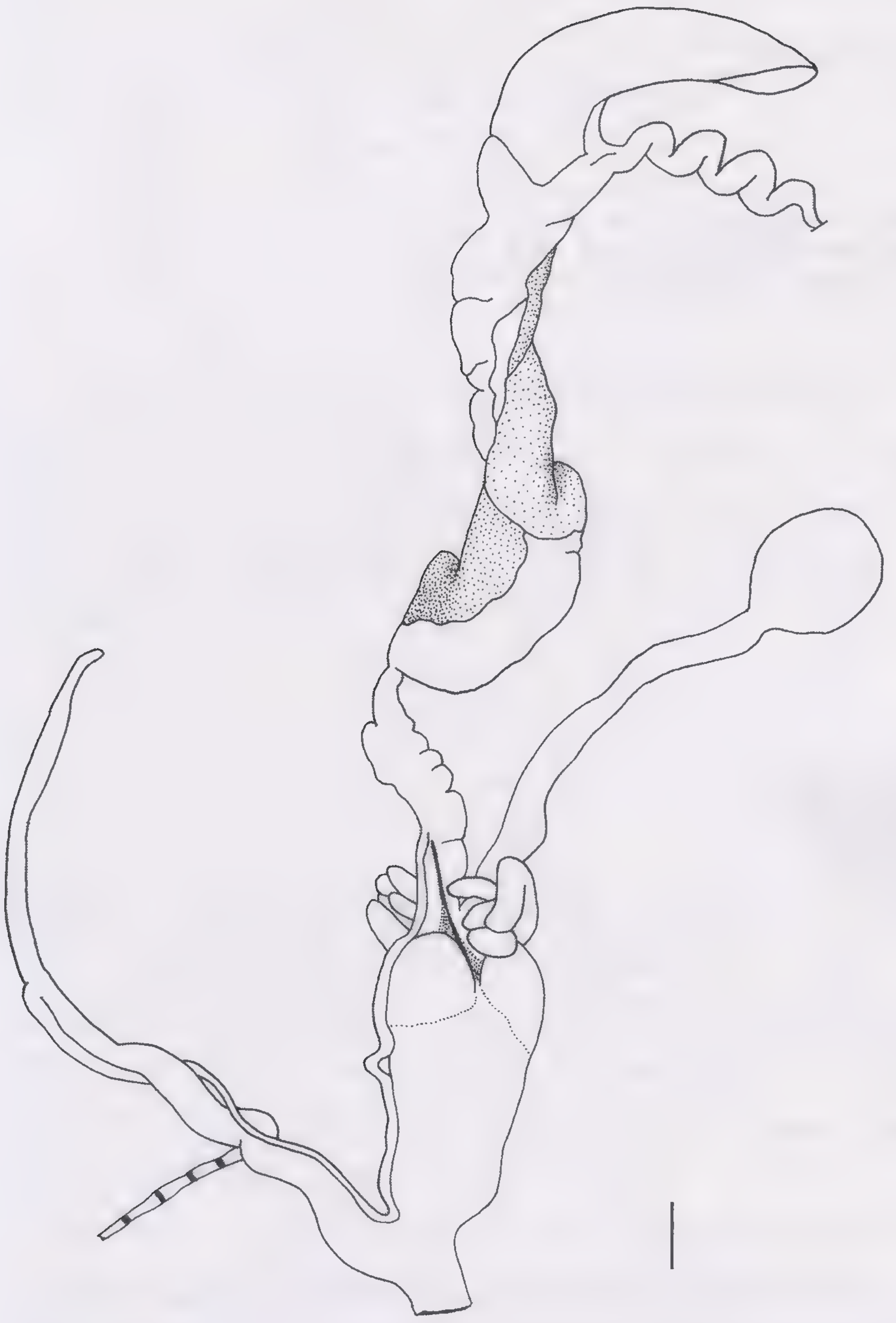

Fig. 2 The genitalia of the specimen of *Helicella cistorum* (Morelet, 1845) collected at the type locality of *Helix semipicta*. Scale bar = 1 mm.

2756 (9 shells) and n° 15.05/2757 (2 shells). Also material of *Helicella cistorum* (Morelet, 1845), has been studied, proceeding from the collection of Ana I. Puente (Fig. 1b), conserved in 70° alcohol from the locality of La Cruz in Linares (Jaén, UTM: VH4422) (MVHN, n°802) (Puente, 1994) and a sample composed of a single specimen collected by Antonio Ortiz de Zárate and deposited in the Siro de Fez collection of the MVHN (n°640) from the locality of Aracena (Huelva, UTM: QB19) (Ortiz de Zárate & Ortiz de Zárate, 1961) (Fig. 1c). Furthermore a study of the reproductive system of the specimen collected alive in Alcaraz has been made following the usual dissection methodology (Muñoz, 1992; Puente, 1994; Arrébola, 1995; Martínez-Ortí, 1999).

RESULTS AND DISCUSSION

THE STUDY OF THE TYPE SERIES OF *HELIX SEMIPICTA* HIDALGO, 1870

The two revised samples, 15.05/2756 and n° 15.05/2757, correspond to the type series of *Helix semipicta* deposited in the MNCN in Madrid, both proceeding from the Hidalgo collection. The authors have named, as a lectotype of this species, the specimen that comes from the sample 15.05/2756 (Figs 1d-f). Its dimensions are 5.33 mm high and 8.90 mm in diameter. The rest of the specimens from both samples deposited in this museum, just as the specimen that the Musée National de Sciences Naturales in Paris (MNHN) possesses, correspond to paralectotypes (Figs 1g-h).

THE STUDY OF THE SHELL AND OF THE REPRODUCTIVE SYSTEM

The conchological comparison of the sample collected by the authors in the *locus typicus* of *Helix semipicta* and the syntypes of this species, deposited in the MNCN, indicate that all the material corresponds to the same taxon. What stands out is the variability observed in the shell's ornamentation in *Helix semipicta*, as specimens have been found that present a slight ribbing and others that present this clearly marked, as well as specimens that do not present careening, or that present it not very marked, until others which are very careened (Fig 1h). In the description of *Helix semipicta* Hidalgo (1870) does not refer to this last characteristic. However Morelet (1845), in the description of *Helix cistorum,* signals that the shells are subcareened, a characteristic that some specimens of *Helix semipicta* (Figs 1g-h) do present.

Furthermore the syntypes of *Helix semipicta* (Figs 1d-h) and those collected by the authors (Fig. 1a), have been compared to specimens of *Helicella cistorum* (Morelet, 1845), that come from the Ana I. Puente (Fig. 1b) and Ortiz de Zárate (Fig. 1c) collections, and their conchological characteristics coincide completely.

The reproductive system study of the specimen collected live has provided greater

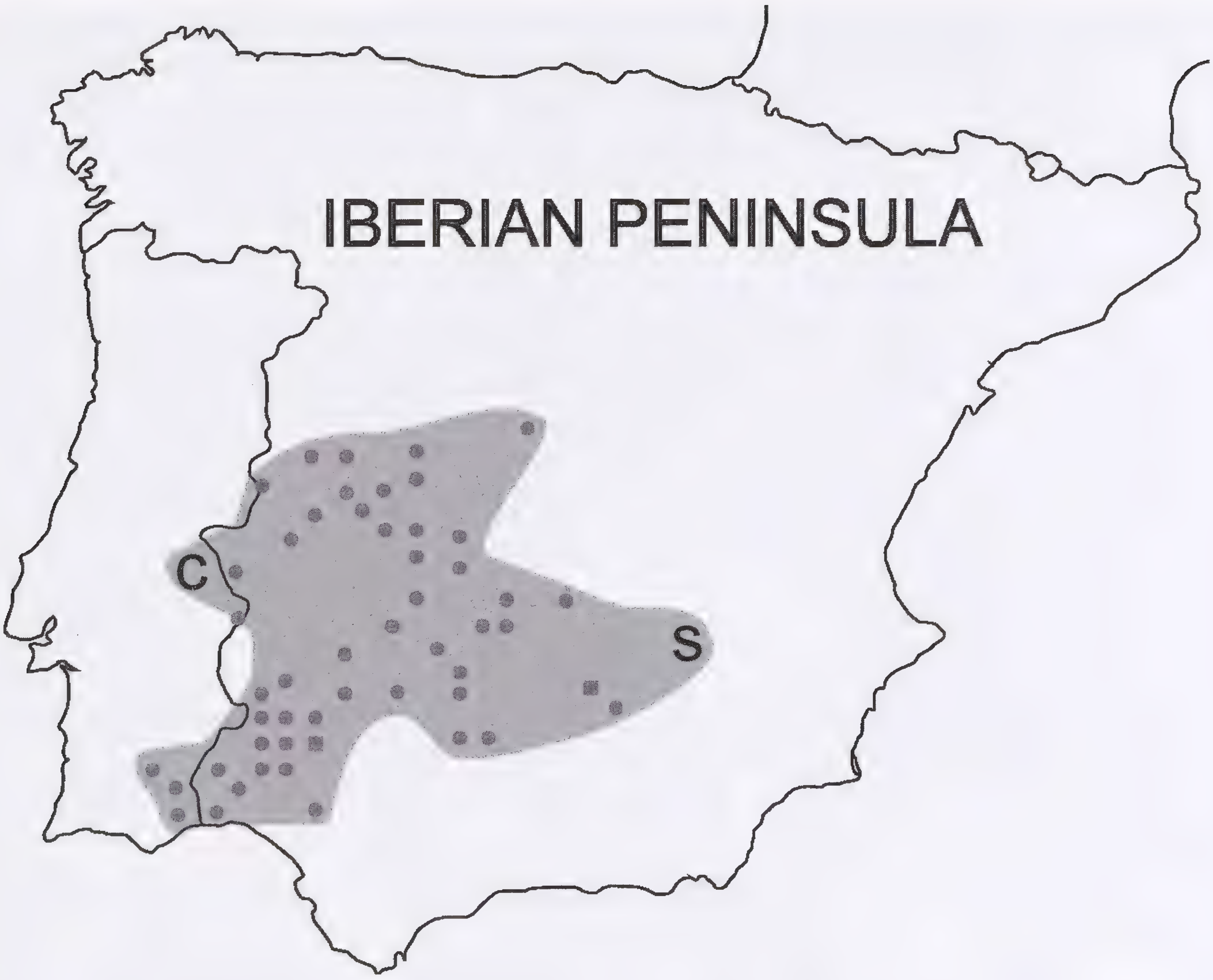

Fig. 3 Geographic distribution of *Helicella cistorum* (Morelet, 1845) based in Puente (1994). C= type locality of *Helix cistorum*; S= type locality of *Helix semipicta* Hidalgo, 1870; dots and squares: quoted localities; squares: Aracena (Huelva, UTM: QB19) (MVHN, n°640) and La Cruz in Linares (Jaén, UTM: VH42) (MVHN, n°802).

information and has allowed its assignment to the Genus *Helicella*, Férussac 1821. The obtained morphology is well characterised and corresponds to that which *Helicella cistorum* (Morelet, 1845) presents (Fig. 2). This has been verified with the reproductive system study of the samples of this species provided by Ana I. Puente and that coincides also with the figures of the genitalia of *Helicella cistorum* in Ortiz de Zárate (1950), Muñoz (1992), Puente (1994) and Arrébola (1995).

CONCLUSIONS

In agreement with the authors' observations on the materials' morphology of the shell and of the reproductive system of *Helix semipicta* Hidalgo, 1870 proceeding from Alcaraz, and its comparison to *Helicella cistorum* material, we conclude that *Helix semipicta* Hidalgo, 1869 should be considered as a junior synonym of *Helix cistorum* Morelet, 1845. Furthermore, the designated syntype, which figures in this report, must be considered the lectotype of *Helix semipicta* Hidalgo, 1870.

Distribution *Helicella cistorum* is an endemic species of the Iberian Peninsula that extends to Alemtejo (*locus typicus*) and the west of the Algarve (Portugal) and through the Spanish provinces of Badajoz, Cáceres, South West of Madrid, Toledo, Ciudad Real, Córdoba, Jaén and Huelva (Muñoz, 1992; Puente, 1994; Arrébola, 1995) (Fig. 3). Therefore the locality of "Alcaraz", *locus typicus* of *Helix semipicta* Hidalgo, 1870, constitutes the first citing of *Helicella cistorum* for the province of Albacete and it is the most oriental locality of the known distribution area of this species, besides being the sample found at the greatest altitude up to now.

ACKNOWLEDGEMENTS

We thank Dr. Oscar Soriano and Miguel Villena of the Museo Nacional de Ciencias Naturales in Madrid for the lending of the Hidalgo collection samples for their study. Also Dr. Ana I. Puente for the sending of comparative material. This report has been partly subventioned by the Instituto de Estudios Albacetenses, through the project 195/96.

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A CONTRIBUTION TO THE KNOWLEDGE OF NORTH KOREAN *GASTROCOPTA* (GASTROPODA: PULMONATA: CHONDRINIDAE)

B.M. Pokryszko[1], E. Stworzewicz[2]

Abstract Gastrocopta coreana *Pilsbry,* G. hirasei *Pilsbry and a new species,* G. nostra, *are recorded from North Korea. Detailed shell descriptions, identification key and taxonomic remarks are provided.*

Key words *Land snails,* Gastrocopta, *North Korea, new species*

INTRODUCTION

Contrary to South Korea, for geopolitical reasons the knowledge of the malacofauna of North Korea is still very scanty. Whatever fragmentary information exists, is contained in very few publications; additionally some guesses can be made based on the expected ranges of species recorded from adjacent areas. South-eastern Asia is one of the diversity centres of the Gastrocoptinae (Pilsbry, 1916-1918), and fairly many species may be expected to occur there.

The malacofauna of the Korean Peninsula has been studied since the second half of the 19th century. Data accumulated till World War Two, concerning investigations of both parts of the peninsula, have been summarized by Kwon (1990). Earlier authors usually did not specify which part of the area was concerned, and most of the sites listed are difficult to locate, since several settlements of the same name are often found in both parts. However, it is very likely that most of these data pertain to sites located along the railway track from Seoul, to the north-west to the Chinese border and southward to Pusan, since this was Kuroda's route during his field studies (Pilsbry, 1927: 417 and map, later repeated by Kwon, 1990).

First mentions of Korean Gastrocoptinae appeared in a paper by Möllendorf (1887) who recorded *G. armigerella* (Reinhardt, 1877) from Seoul (S Korea) and Hatong (N Korea). Pilsbry (1916-1918) mentioned *G. armigerella* from the same localities, and added *G. coreana* Pilsbry, 1916 and *G. hirasei* Pilsbry, 1916, both from the island of Kojedo (S Korea), to the list. Later, Kuroda and Hukuda (1944) described *G. jinjiroi* from the island of Ullung (S Korea). In his 1979 and 1981 papers Kwon (Kwon and Habe, 1979; Kwon, 1981) listed four species: *G. armigerella, G. coreana, G. hirasei* and *G. jinjiroi*, but in his later publications (Kwon, 1990; Kwon *et al*. 1993) the number was mysteriously reduced by half (*coreana* and *jinjiroi*). Kwon's (1990) records were based on data from Pilsbry (1916-1918, 1926), Shiba (1934), Kuroda (1963), Yoo (1976), Kwon (1981) and Azuma (1982), from the following localities: *coreana*: Kojedo (S Korea), Yosu (S or N Korea), Tanyang (S Korea), Ch'ongp'yong (S Korea), Hwach'on (S or N Korea), Cheju-do (S Korea), Kunsan (S or N Korea), Ch'ongju (S or N Korea), *jinjiroi*: Ullung-do (S Korea). A short paper by Stworzewicz (1997), with a mention of *G. coreana* and *hirasei*, and an unpublished doctoral thesis of the University of Pyongyang (Pak, 1986), cited by that author and mentioning *G. armigerella* from Pyongyang, complete the list of available sources of information on N Korean gastrocoptines.

As a result of Polish zoological investigations in North Korea (Mroczkowski, 1972; Pawłowski and Tomek, 1997; Pawłowski *et al.*, 2000), which included 21 consecutive

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[1] Museum of Natural History, Wrocław University, Sienkiewicza 21, 50-335 Wrocław, Poland (e-mail: bepok @culex.biol.uni.wroc.pl).

[2] Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Sławkowska 17, 31-016 Kraków, Poland (e-mail: stworzewicz@isez.pan.krakow.pl).

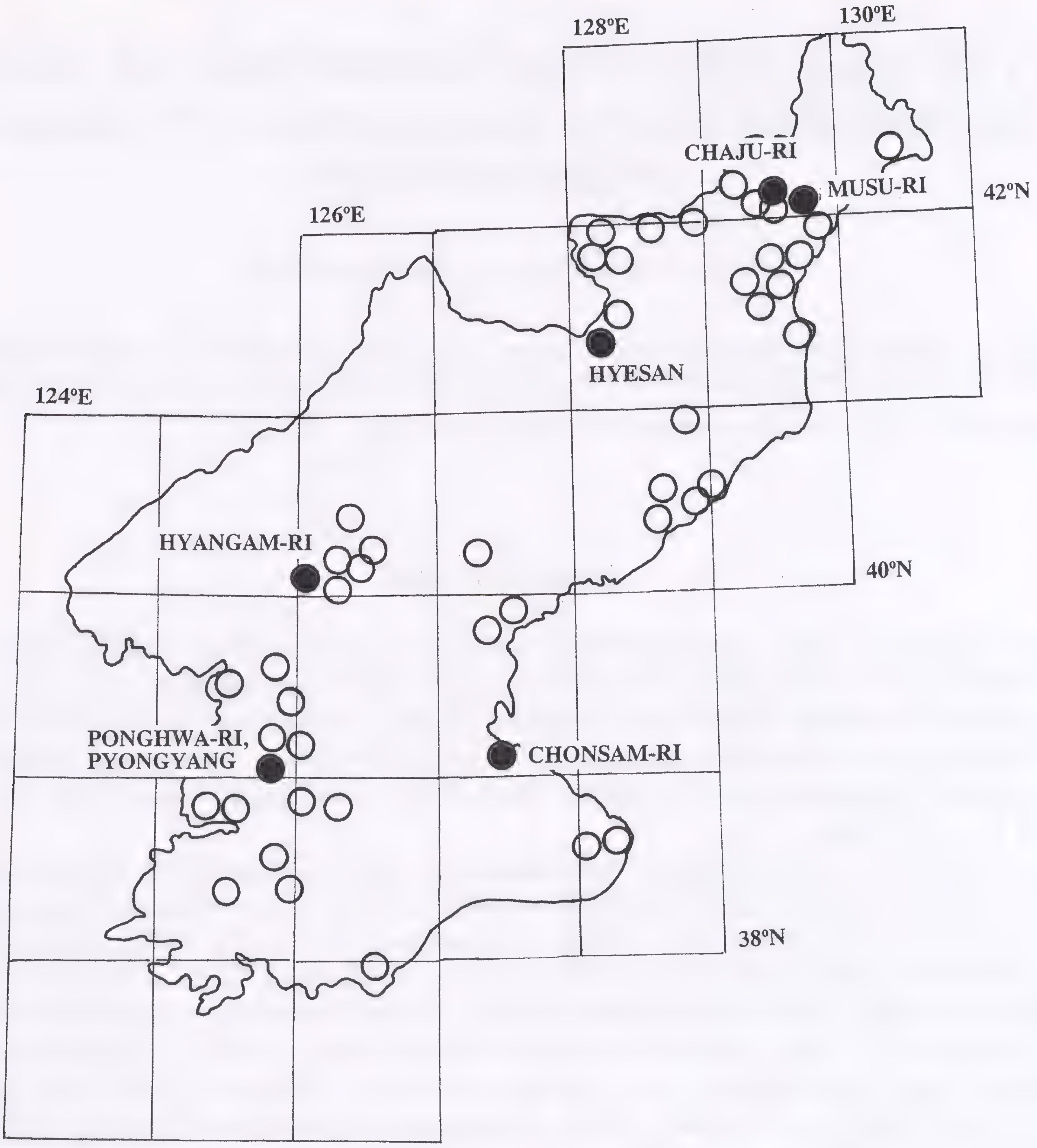

Figure 1 Gastropod localities investigated during the Polish expeditions to N Korea; solid circles denote records of *Gastrocopta*. Some of the circles denote more than one locality

expeditions (five of these resulting in malacological collections) the first of which took place in 1965, new materials of *Gastrocopta* accumulated, originating from several localities (Fig. 1). Among them there was a series of shells representing a new species which we describe below. The scanty knowledge of N Korean snail fauna and the difficulties implied usually in identifying species of *Gastrocopta*, induced us to supplement our paper with descriptions of and identification key to all the known N Korean species. Because of frequent misidentifications (see Discussion) we thought it advisable to include *G. armigerella* (Reinhardt, 1877) and *G. meridionalis* (Möllendorff, 1884) in our key.

The following abbreviations of repositories are used in the text:

BMNH - The Natural History Museum, London;
ISEZ PAN - Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Cracow;
MiIZ PAN - Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw;
MPWr - Museum of Natural History, Wrocław University;
SMF - Senckenberg Institut, Frankfurt aM.

Identification key

1. Columellar tooth located high on columellar wall, very close to parietal wall 2
- Columellar tooth located at half height of columellar wall, horizontal, infraparietal tooth - when present - tubercular 3

2. Parietal part of parietoangular tooth high (higher than angular) and long, angular part strongly bent palatalwards, sometimes even upturned, inner part of columellar tooth at right angle to the outer part, arranged vertically, infraparietal tooth lamellate .... *hirasei*
- Parietal part of parietoangular tooth not higher than angular part, and rather short, angular part slightly bent palatalwards, inner part of columellar tooth only slightly arcuately bent downwards, infraparietal tooth tuberculate .... *armigerella*

3. Infraparietal tooth present, shell not higher than 2.20 mm ....*coreana*
- Infraparietal tooth absent, shell higher than 2.20 mm 4

4. Shell ovate, tumid, with ca. 4.5 whorls and blunt apex, not higher than 2.50 mm ....*meridionalis*
- Shell elongatedly-oval, slender, with at least 5 whorls and rounded apex, at least 2.80 mm high .... *nostra* sp. nov.

Gastrocopta nostra sp. nov.
Figs 2, 3

Material examined Ponghwa-ri (39°13'N, 126°00'E), Pyongan prov., 5 June 1987, leg. E. Stworzewicz, 59 spec.: holotype & 21 paratypes ISEZ PAN, 5 paratypes MiIZ PAN, 5 paratypes MPWr, 2 paratypes BMNH, 2 paratypes SMF, 23 juvenile and/or damaged shells ISEZ PAN. Comparative material: *G. bathyodon* (Benson, 1863): Nerbudda Valley, Central Prov., India, 4 spec., BMNH no. 19991572 and 4 spec., BMNH 19991584; Hoshangabad, nr. Nerbudda River, India, Benson's cotype, BMNH 19991573; *G. meridionalis* (Möllendorff, 1884): Sha-ming near Macao, China, 1 spec. labelled as "paratypoid" of *G. meridionalis*, SMF 4568, collection Möllendorff; Hongkong, Shekko, China, 1 spec., SMF ex 42107/1, collection Möllendorff.

Type Locality N Korea, Pyongan province, Ponghwa-ri (39°13'N, 126°00'E).

Derivation of name *nostra* is Latin for ours; we christen it so in honour of our co-authorship.

Diagnosis The species seems to be the closest to *G. bathyodon* (Benson, 1863) from India and *G. meridionalis* (Möllendorff, 1884) from China. It differs from the former species in 1. more slender and less conical shape; 2. thinner, more fragile and more translucent shell with no trace of brown colour; 3. much narrower umbilicus; 4. completely fused parietoangular tooth, only very rarely "bifid" and when so, parietal and angular apices never divergent; 5. parietal callus thin and not detached from body whorl. *G. meridionalis* differs in 1. smaller size (shell height 2.40 mm compared to at least 2.80 in the new species); 2. more tumid and more ovate shape; 3. relatively larger aperture; 4. relatively higher body whorl; 5. fewer whorls (slightly over 4.5 compared to at least 4.8 in the new species); 6. much blunter, almost truncate apex.

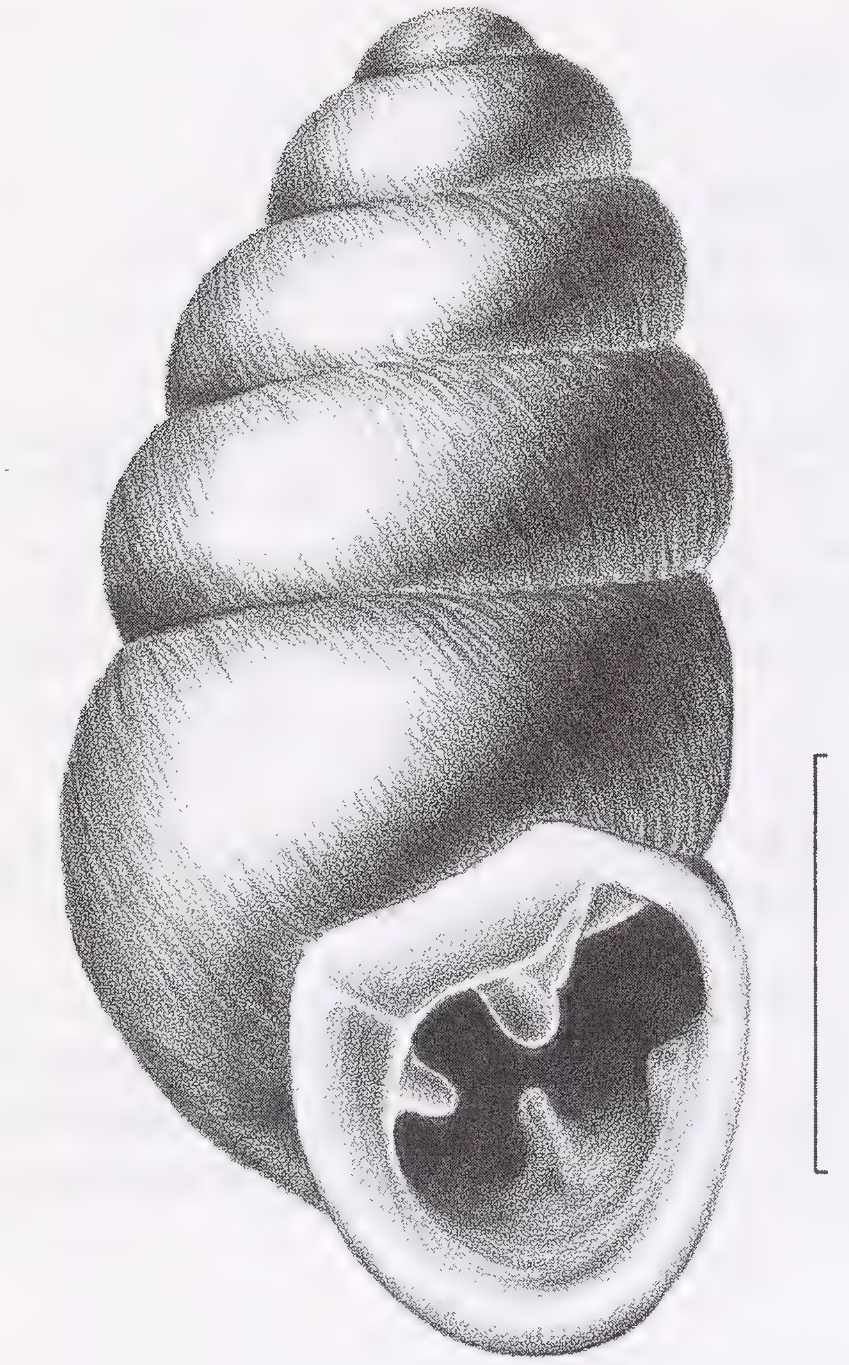

Figure 2 *Gastrocopta nostra* sp. nov., front view of the holotype. Scale bar 1 mm

Description Dextral, ovate-conical, relatively slender (except the few shorter specimens), with 4.8-5.5 (mean 5.3, SD 0.16, n = 34; holotype 5.4) whorls, most often 5.2-5.4 whorls; whorls varying from moderately convex to convex, suture from moderately deep to deep; apex evenly rounded. Measurements: shell height 2.80-3.42 mm (mean 3.19, SD 0.13, n = 34; holotype 3.20), shell breadth 1.50-1.63 mm (mean 1.58, SD 0.03, n = 34; holotype 1.60), aperture height 1.10-1.27 mm (mean 1.21, SD 0.05, n = 34; holotype 1.20), aperture breadth 1.03-1.13 mm (mean 1.06, SD 0.02, n = 34; holotype 1.07), body whorl height 1.70-1.90 (mean 1.77, SD 0.05, n = 34; holotype 1.80), height/breadth ratio 1.83-2.17 (mean 2.02, SD 0.08, n = 34; holotype 2.0), relative height of body whorl 0.51-0.61 (mean 0.55, SD 0.02, n = 34; holotype 0.56). Umbilicus very narrow, deep, open. Aperture varying from oval to subquadrate, with no trace of palatal incision, at most a flattening of the palatal margin; sinulus absent; lip fairly wide, not thickened, gently reflexed, parietal callus not detached from the body whorl. Apertural barriers composed of 4-5 rather subtle, thin and straight teeth, and no callus. Columellar tooth located roughly at half height of columellar wall, short, horizontal lamellate of regularly arcuate margin, rarely as a horizontally oriented, flattened tubercle; parietoangular tooth completely fused, so that its parietal and angular parts are located almost in line, and composed of two parts: a deeper situated thin, short lamella of regularly arcuate margin, corresponding to the parietal, and a more externally situated lower lamella, in most shells prolonged to the lip edge as a low ridge; in very few shells these two parts are partly separated by a shallow incision; upper palatal tooth very short and low lamellate, or tubercular; lower palatal tooth longer, higher and thicker lamellate, in some shells its margin thickened; besides ca. 50% (16 out of 34) shells have a basal tooth (in holotype absent), located in basal position, tuberculate and vestigial, only in one shell more pronounced. Body whorl in side view with no or, rarely, with only a vestigial crest; with no imprints corresponding to the palatals, only flattened, or with an almost imperceptible imprint corresponding to the lower palatal tooth. Colour semitransparent greyish-white, in older shells opaque white; apertural barriers white. Shell surface sculpture of very delicate, somewhat irregular radial lines.

Distribution N Korea, known from the type locality only.

Gastrocopta coreana Pilsbry, 1916

Fig. 3

Material examined Ponghwa-ri (39°13′N, 126°00′E), Pyongan prov., 5 June 1987, leg. E. Stworzewicz, ISEZ PAN, 9 spec.; Tanchon (40°27′N, 128°54′E), Hamgyong prov. June, 1987, leg. E. Stworzewicz, ISEZ PAN, 4 spec.; Chaju-ri (42°07′N, 129°26′E), Hamgyong

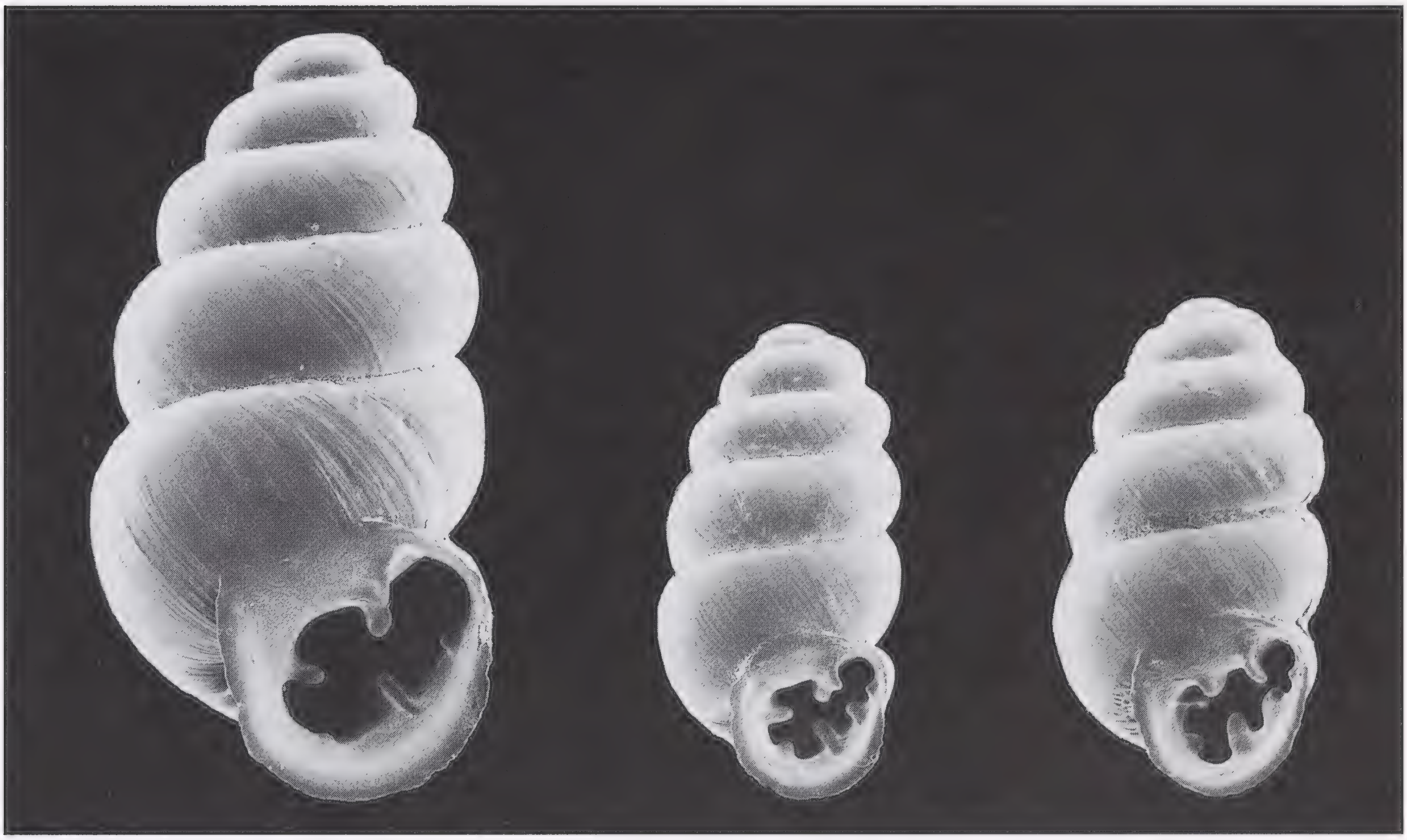

Figure 3 *Gastrocopta nostra* sp. nov., paratype, ISEZ PAN, shell height 3.33 mm (left), *G. coreana* Pilsbry from Musu-ri, MiIZ PAN, shell height 2.07 mm (centre), *G. hirasei* Pilsbry from Pyongyang, ISEZ PAN, shell height 2.13 mm (right)

prov., 29 June, 1983, leg. E. Stworzewicz, ISEZ PAN, 7 spec.; Chonsam-ri (39°09’N, 127°25’E), Kangvon prov., 3 September 1966, leg. C. Dziadosz & H. Szelęgiewicz, MiIZ PAN, 1 spec.; Hyangnam-ri (40°02’N, 126°11’E), Hyangsan prov., 16 June 1965, leg. A. Mroczkowski & A. Riedel, MiIZ PAN, 4 spec.; Hyesan (41°24’N, 128°10’E), Ryanggang prov., 1 October 1991, leg. E. Stworzewicz, 1 spec.; Musu-ri (42°08’N, 129°39’E), Chondzin-si prov., 1 June 1965, leg. M. Mroczkowski & A. Riedel, MiIZ PAN, 4 spec.

Description Dextral, elongated, almost cylindrical, slender, with 5.0-5.3 (mean 5.13, SD 0.09, n = 12) whorls, most often 5.1-5.2 whorls; whorls moderately convex, suture moderately deep; apex rounded. Measurements: shell height 1.83-2.10 mm (mean 1.98, SD 0.08, n = 12), shell breadth 0.90-1.03 mm (mean 0.96, SD 0.04, n = 12), aperture height 0.63-0.73 mm (mean 0.69, SD 0.04, n = 12), aperture breadth 0.57-0.67 mm (mean 0.63, SD 0.03, n = 12), body whorl height 1.00-1.13 mm (mean 1.06, SD 0.05, n = 12), height/breadth ratio 2.00-2.20 (mean 2.08, SD 0.07, n = 12), relative height of body whorl 0.52-0.56 (mean 0.54, SD 0.01, n = 12). Umbilicus very narrow, deep, open. Aperture rounded-subquadrate, with a barely marked or no palatal incision, at most a flattening of the palatal margin; sinulus present but indistinct; lip moderately wide, not thickened, gently reflexed, parietal callus not detached from the body whorl. Apertural barriers composed of 6-7 moderately robust teeth; on palatal wall callus developed at the very bases of teeth. Columellar tooth located at ca. half height of columellar wall or somewhat higher, moderately thick lamellate, straight and horizontally oriented; infracolumellar tooth (or basal tooth in infracolumellar position) as a fine tubercle of narrow base and arcuate margin; parietoangular tooth composed of two equally well developed, lamellate, incompletely fused parts: angular part fairly low, slightly bent palatalwards, prolonged to the very margin of lip as a low ridge, or terminating close to it; parietal part, separated from the angular part by a fairly deep incision, is higher but fairly short, of regularly arcuate margin, in top view straight, in front view tips of both these parts clearly divergent; upper palatal tooth in the form of a short, rather high and moderately thick lamella, parallel to the lower palatal tooth; lower palatal tooth high and moderately thick lamellate, ca. twice longer than the upper; suprapalatal tooth tuberculate; infraparietal tooth small tuberculate, vestigial (5 out of 12 shells) or absent (7 shells). Body whorl in side view with no imprints corresponding to the palatals, only slightly flattened, or with a very delicate imprint corresponding to the lower palatal tooth; crest vestigial or absent. Body whorl suture not ascending, parallel to the suture above. Colour semitransparent greyish-white, in older shells opaque white; apertural barriers white. Shell surface sculpture of very delicate, somewhat irregular radial lines.

Distribution Korean Peninsula (Pilsbry 1916-1918, Kwon 1990).

Note Likharev and Rammelmeyer (1952), and later Shileyko (1984) synonymized *G. coreana* with *G. theeli* (Westerlund, 1877), albeit without any comment. The two species appear to be very similar but the problem requires a more detailed approach based on examination of the types and a more extensive material representing the whole variability range.

Gastrocopta hirasei Pilsbry, 1916
Fig. 3

Material examined Pyongyang (39°01'N, 125°44'E), Pyongan prov.: 15 September 1971, leg. A. Szeptycki, ISEZ PAN, 18 spec.; 18 May 1974, leg. A. Szeptycki, ISEZ PAN, 1 spec.; 26 May 1974, leg. A. Szeptycki, ISEZ PAN, 4 spec.; Ponghwa-ri (39°13'N, 126°00'E), Pyongan prov., 5 June 1987, leg. E. Stworzewicz, ISEZ PAN, 16 spec; 4 June 1987, leg. E. Stworzewicz, ISEZ PAN, 18 spec.; Hyangnam-ri (40°02'N, 126°11'E), Myohyangsan, Hyangsan prov., 16 June 1965, leg. A. Mroczkowski & A. Riedel, MiIZ PAN, 10 spec.

Description Dextral, elongatedly-oval, tumid, with 4.8-5.8 (mean 5.23, SD 0.22, n = 33), most often 5.2-5.3 whorls; whorls moderately convex, suture moderately deep; apex rounded. Measurements: shell height 1.80-2.40 mm (mean 2.13, SD 0.18, n = 33), shell breadth 0.97-1.17 mm (mean 1.07, SD 0.07, n = 33), aperture height 0.63-0.90 mm (mean 0.76, SD 0.09, n = 33), aperture breadth 0.60-0.80 mm (mean 0.78, SD 0.07, n = 33), body whorl height 1.00-1.30 mm (mean 1.15, SD 0.09, n = 33), height/breadth ratio 1.80-2.20 (mean 1.99, SD 0.10, n = 33), relative height of body whorl 0.51-0.65 (mean 0.54, SD 0.03, n = 33). Umbilicus very narrow, deep, open. Aperture varying from roundedly-triangular to subquadrate, with no trace of palatal incision, at most a flattening of the palatal margin; sinulus distinct since the perietoangular and upper palatal teeth almost meet; lip moderately wide, not thickened, gently reflexed, parietal callus not detached from the body whorl. Apertural barriers composed of 6-7 robust teeth, which considerably occlude the aperture; on palatal wall callus well-developed at the base of teeth. Columellar tooth located very high on columellar wall, close to the parietal wall: its half closer to the aperture is horizontally oriented, its well-developed, deeper situated part forms an almost right angle with the outer part and as a result runs vertically; in front view spoon-like concave; infracolumellar tooth (or basal tooth in infracolumellar position) as a prominent high tubercle of broad base and arcuate margin; infraparietal tooth lamellate of regularly arcuate margin, rather long and high; parietoangular tooth composed of two equally well developed, lamellate, incompletely fused parts: angular part high and large, strongly bent palatalwards, in some specimens even upturned, terminating rather abruptly; parietal part, separated from the angular part by a fairly deep incision, is even higher and longer, of regularly arcuate margin, in top view arcuately bent, well visible in front view; upper palatal tooth in the form of a short, rather high and thick lamella, in front view incisive-like as a result of being situated obliquely; lower palatal high and thick lamellate, ca. twice longer than the upper; additonally most (23 out of 33) shells have a suprapalatal tooth: either short and low lamellate (18 shells) or tubercular (5 shells). Body whorl in side view with no imprints corresponding to the palatals, only slightly flattened; crest absent. Body whorl suture not ascending, parallel to the suture above. Colour semitransparent greyish-white, in older shells opaque white; apertural barriers white. Shell surface sculpture of very delicate, somewhat irregular radial lines.

Distribution China (Pilsbry, 1916-1918) and the Korean Peninsula.

Notes In 1944 Kuroda and Hukuda described *G. jinjiroi* from the island of Ullung in South Korea. Later authors (cf. Kwon, 1990) mentioned only that species but not *G. hirasei*, and only from its type locality. Kwon identified our samples as *G. jinjiroi*. The type of *G. jinjiroi* could not be located; all our specimens correspond to Pilsbry's *G. hirasei*, and we have identified them accordingly. Whether these two names prove to be synonyms, or Kuroda and Hukuda (1944) in South Korea dealt with quite a different species, is a matter for future investigations.

G. hirasei and *coreana* are somewhat similar and no doubt closely related to *G. armigerella* from China, Japan (Pilsbry, 1916-1918) and some islands of Indonesia (Pokryszko, unpublished). *G. hirasei* differs in the parietal part of parietoangular tooth being higher, its angular part more bent palatalwards, the inner part of columellar tooth much more bent downwards, and a lamellate infraparietal tooth. *G. coreana* differs mostly in much subtler teeth. The general impression given by armigerella is that of a *hirasei* with somewhat subtler apertural barriers, or a *coreana* with a slightly exaggerated armature, hence the possibility of misidentification. Some authors (Möllendorff, 1884; Pilsbry 1916-1918: repeated Möllendorff's record) reported *G. armigerella* from Korea. In his 1990 book Kwon did not mention *G. armigerella*, but listed some earlier records of coreana with a comment "as *armigerella*". Thus in all likelihood the Korean records of *G. armigerella* are based on a misidentification of *hirasei* or *coreana*.

DISCUSSION

A majority of North Korean land snail species are known also from adjacent areas of China, Japan and Primorskiy Kray (Russia) (Pilsbry, 1908; Stworzewicz, 1997); the fauna includes many species that are absent from the much better studied South Korea. Contrary to South Korea, there is little resemblance to the Oriental fauna. Thus, when trying to make guesses about further species of *Gastrocopta* to be expected in North Korea, one should refer to faunal lists of these former areas. Pilsbry (1916-1918) mentions the following taxa: from Japan: *G. chichijimana* Pilsbry, *G. chichijimana ogasawarana* Pilsbry, *G. hachijoensis* Pilsbry, *G. armigerella* (Reinhardt) and from China: *G. armigerella* (Reinhardt), *G. monadicula* (Heude), *G. meridionalis* (Möllendorff), *G. ejecta* (Bavay et Dautzenberg). Shileyko (1984) lists *G. theeli* (Westerlund) from Primorskiy Kray. Even considering the possibility of misidentification of *G. armigerella* (see also notes under *hirasei*) and the possible synonymy of *theeli* and *coreana* (see note under *coreana*), further members of *Gastrocopta* can be expected in North Korea. On the other hand, the fact that the three species discussed in this paper were found at seven out of the total of 50 investigated snail sites may indicate that *Gastrocopta* is not frequent in the area.

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AN UNUSUAL FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* (L.) POPULATION IN SCOTLAND

PETER J. COSGROVE[1] & PAUL V. HARVEY

Abstract The physical microhabitat requirements of freshwater pearl mussels Margaritifera margaritifera *(L.) are now well known. Freshwater pearl mussels live buried or partly buried in clean, mixed stable substrate in fast-flowing unpolluted streams and rivers and subsist by inhaling and filtering water for the minute organic particles on which they feed. In 2002, a chance finding by a local crofter of live mussels in Shetland led to the discovery of a reproductively viable mussel population in peat dominated substrate in predominantly dry fen habitat. The physical habitat characteristics of the unusual Shetland site are contrasted and compared with conventional* M. margaritifera *habitat. The fen habitat and peat substrate used by the mussels are so atypical of that favoured by* M. margaritifera *elsewhere, that this is believed to constitute the first substantiated record of mussels using such a habitat.*

Key words Substrate, physical microhabitat, fen, hydrology, Shetland

INTRODUCTION

During the past 100 years, the freshwater pearl mussel *M. margaritifera* (L.) has declined throughout its Holarctic range to such an extent that it is now listed as an endangered species (IUCN 1991). Scotland is a major European and global stronghold for *M. margaritifera*, with recent estimates suggesting that Scotland holds perhaps half of the world's known remaining viable populations (Cosgrove, Young, Hastie, Gaywood and Boon 2000a; Young, Cosgrove and Hastie 2001a). However, the species has declined in Scotland for a number of reasons, including gross industrial and agricultural pollution, over-exploitation by pearl fishermen, decline in salmonid host stocks and physical river bed habitat degradation due to hydro-electric operations and small-scale river engineering works (Cosgrove *et al.* 2000a).

Most *Margaritifera* populations in Scotland were identified during preliminary work for the 1998 Scottish national survey of freshwater pearl mussels. During the survey, one Shetland watercourse was identified as being a historical *M. margaritifera* site on the basis of two old records (Cosgrove 1997). To maintain site confidentiality because of the on-going threat from illegal pearl fishing, the Shetland site is described in this paper as 'Burn A'. The first known record from this site referred to several specimens dated 1849. In 1929, Oldham removed several mussels from the same location (Tallack 1995). Since then, three extensive searches of Burn A in 1993-1994 by R.M. Tallack (Tallack 1995) and one by P.J. Cosgrove on 24/09/96 failed to find any sign of mussels (Cosgrove and Young 1998). Then, in early 2002, a local crofter found a "*mussel-like creature*" he could not identify in a side channel of Burn A. The specimen was *M. margaritifera* and when P.V. Harvey, of the Shetland Biological Records Centre (SBRC) visited the site in late May 2002, a brief search revealed five live freshwater pearl mussels.

Based on these recent findings and in recognition of the continuing decline of the freshwater pearl mussel in Great Britain and the rest of Europe, the Shetland Biological Records Centre commissioned this study. The study focussed on surveying Burn A and identifying and searching a number of other Shetland burns that might potentially hold unsurveyed and unknown freshwater pearl mussel populations.

Corresponding author[1]: Coilintra House, High St., Grantown on Spey, Morayshire, PH26 3EN E-mail: petercosgove@cairngorms.co.uk.

Photo 1 Surveying the lower main stem of Burn A, fen habitat, Shetland 2002. ©Peter Cosgrove.

METHODOLOGY

SITE SELECTION

Due to the recent discovery of live mussels, the surveyors concentrated search efforts in the Burn A catchment. The surveyors also briefly searched five other potentially suitable burns in Shetland.

SEARCH METHODS:

One team of two fieldworkers carried out the survey to optimise search efficiency and for health and safety reasons. The main stem of Burn A (c2.5km in length and 1-2m in width), and a small 150m side channel were entered and searched for freshwater pearl mussels using the standard freshwater pearl mussel survey protocols, as described in Young *et al.* (2001b). The standard methodology is based on a stratified visual search of a sample of potentially suitable sites throughout the main stem of the river/burn and any suitable side channels.

RESULTS

BURN A

Main stem

Almost the entire main stem of Burn A was surveyed for freshwater pearl mussels on the 2-3rd August 2002 by P.J. Cosgrove and P.V. Harvey. Much of the lower section of the main stem (c700m) flowed through an extensive area of rank and impenetrable fen habitat and made standard transect survey protocols impossible to carry out. Consequently, a series of spot checks were carried out whenever the fen vegetation (predominantly Meadowsweet *Filipendula ulmaria* (L.) and Bogbean *Menyanthes trifoliata* (L.)) allowed access. Live mussels were found scattered at low densities in one very short (30m) section. The substrate was dominated by peat, but included some small areas of mixed substrate composition thinly deposited upon the peat (Table 1).

Above the area of fen habitat and 10m above the upper confluence with a small side channel the burn '*opened out*', where it had been recently dredged. Approximately 150m of the channel had been recently dredged and ten live mussels were discovered in this section. Above the recently dredged stretch, c400m of the burn had been dredged 7-8 years ago upstream all the way to a bridge and no mussels were found when this area was searched. Although the substrate of 1km of the main stem of the burn above the bridge appeared ideal 'conventional' *M. margaritifera* habitat (Table 1), mussels were inexplicably and completely absent in this section. The upper most 300m of the main stem of Burn A was not surveyed.

Side channel

A search was conducted in a small un-dredged side channel (<1m wide) that left the main stem of Burn A and went through an extensive area of fen habitat. Most of the 150m side channel was completely dry, composed of peat and wholly unsuitable (no water) for mussels (Table 1). Occasionally very small springs or seepages flowed out from the fen habitat and a trickle of water (usually less than 10m long, <0.1m deep) flowed on one side of the channel before drying out or disappearing into holes in the peat. Very small patches of sands and gravels occasionally had been deposited on top of the peat (Table 1). Remarkably, trout fry and c30 live mussels were found in these short seepage flows, which also contained some small granule and sand substrate material (Table 1). Eventually the side channel rejoined the main stem of the burn, but this area was deep (> 2m), dominated by Bogbean and was not searched.

TABLE 1

Substrate composition (% cover) of the main stem and side channel of Burn A, Shetland, August 2002.

Site	**Bedrock solid**	**Boulder >256 mm**	**Cobble 64-256 mm**	**Pebble 4-64 mm**	**Granule 2-4 mm**	**Sand 0.5-2mm**	**Silt / Peat <0.5mm**
Upper 1km of main stem, not dredged, above bridge.	10%	25%	25%	15%	15%	10%	+
Middle 400m of main stem, historically dredged below bridge.	0	+	10%	30%	30%	30%	+
Middle 150m of main stem, recently dredged.	0	+	20%	20%	30%	30%	20%
Small 150m side channel, (fen habitat).	0	+	+	+	10%	15%	75% (solid peat)
Lower 700m of main stem, not dredged, below bridge (fen habitat).	0	+	5%	10%	20%	15%	50%

+ = present but less that 5% of substrate composition

Unfortunately, the vegetation was so rank and impenetrable that it was not possible to survey the entire fen channel in any systematic manner using a glass-bottomed viewing bucket. The rank vegetation (mainly Meadowsweet) completely covered the fen channel form (which was not even visible from the surface of the fen), so the surveyors had to crawl on their hands and knees underneath the overhanging vegetation in relative darkness. The lack of light and water sufficiently deep water for using a viewing bucket

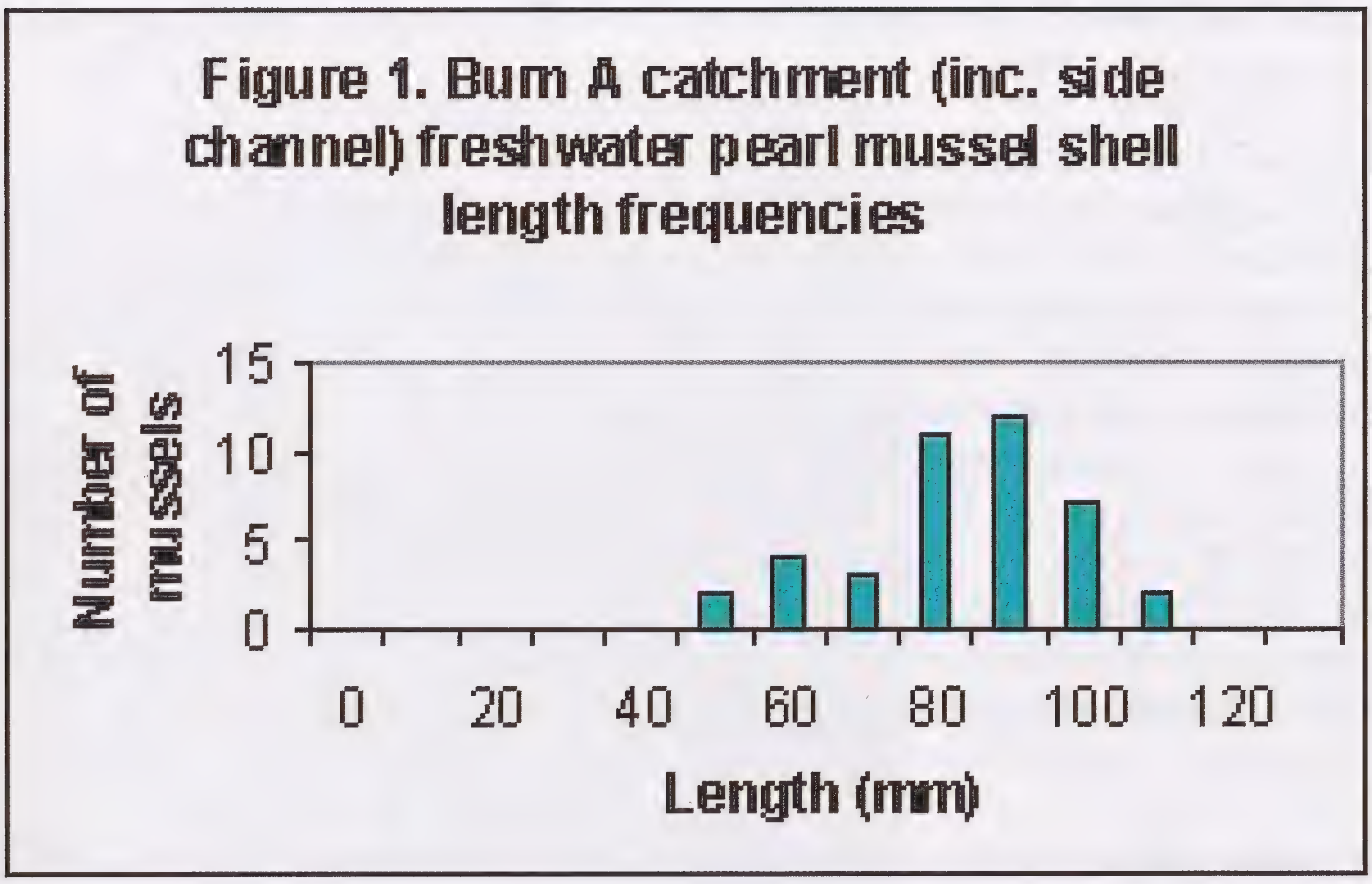

Figure 1. Burn A catchment (inc. side channel) freshwater pearl mussel shell length frequencies

meant that surveyors had to use their hands to feel for mussels in the darkness.

All 10 mussels discovered in the main stem of Burn A and 31 in the small side channel were measured (Figure 1). Using standard criteria for describing the conservation status of a *M. margaritifera* population (Cosgrove *et al.* 2000a), the Burn A catchment mussel population can be described as '*currently viable*', due to the presence of juvenile mussels in the sample surveyed. It was not possible to formally ascribe a relative abundance term to the Burn A mussel population, as these terms are based around standard transects which were not carried out due to the unusual nature of the site and the practical difficulties posed by the rank vegetation.

It is interesting to note that no juvenile mussels below 50mm were recorded in the sample measured (Figure 1). Three dead mussel shells were also found and these have been lodged with the Shetland Biological Records Centre.

Other selected sites

The surveyors briefly searched five other potentially suitable burns on Shetland mainland between 02/08/02 – 05/08/02. Although all five burns contained salmonid fish populations and areas of potentially suitable habitat, no mussels were recorded.

DISCUSSION

INTERPRETATION OF RESULTS

The discovery of a viable freshwater pearl mussel population at Burn A after the last positive sighting in 1926 is very surprising. Despite surveying some apparently suitable burns, no other known *M. margaritifera* populations exist in Shetland and the Burn A discovery is all the more remarkable considering the number of recent negative searches for the species at the site in the last decade. The nearest viable mussel populations are probably those of the rivers in Sutherland, Scotland or possibly even Norwegian sites. Therefore, Burn A is the most northerly site in Great Britain and Ireland for *M. margaritifera* and constitutes an important outlying population.

Normally, freshwater pearl mussels live buried or partly buried in clean, fast-flowing unpolluted streams and rivers and subsist by inhaling and filtering for the minute

Photo 2 Side channel, rank fen vegetation completely covers channel form, Shetland 2002. ©Peter Cosgrove.

organic particles on which they feed (Cosgrove, Hastie and Young 2000b). Recently, Hastie, Boon and Young (2000), investigated the relationship between mussels and several physical habitat parameters (distance from nearest bank, mean water depth, mean current velocity, substratum descriptors and aquatic vegetation cover) and reviewed all the available literature. According to Hastie *et al.* (2000), adult and juvenile mussels tend to have similar habitat 'preferences', although adults are found over a wider range of physical conditions and juveniles appear to be more exacting in their requirements and sensitive to environmental disturbance. Optimum water depths for mussels in Scotland were estimated at 0.3-0.4m and optimum current velocities of 0.25-0.75ms^{-1} at intermediate water levels.

River bed substratum characteristics appear to be the best physical parameters for describing *M. margaritifera* habitat. Freshwater pearl mussels prefer stable cobble/boulder dominated substrate with some fine sand and gravel substrate that allows the mussels to burrow. Juvenile mussels prefer finer stable sediments than adults, particularly dominated by clean, well aerated sand and gravel. Of specific importance to mussel survival are levels of silt, suspended solids, calcium and chemical compounds generally associated with enrichment (eutrophication) i.e. nitrate, phosphate and biological oxygen demand (Bauer 1983).

The only historical data for Burn A relate to several specimens in the National Museums of Scotland (dated 1849) and the account of Oldham from 1929 when, in a letter, he gave a detailed site description indicating that the mussels were living among the roots of Bogbean. The 1929 letter therefore indicates that the use of this previously unrecorded mussel habitat in the side channel and lower main stem is longstanding and not related to a recent change. The fen habitat and peat substrate used by the mussels are so atypical of that favoured by *M. margaritifera* elsewhere, that this is believed to constitute the first substantiated record of mussels using this habitat. However, mussels have been recorded in peat substrate on the Western Isles and the west coast of mainland Scotland, but this has always been in burns with significant conventionally suitable habitat in adjacent areas and plenty of clean running water (*pers obs.*). Consequently, Burn A's *M. margaritifera* population is quite unique in a British and European context.

The presence of juvenile mussels (Figure 1) in the Burn A population is all the more remarkable since the side channel apparently contained only small patches of suitable substrate – as conventionally defined (Table 1) and these thin patches lay on top of a solid peat substrate. According to Hastie *et al.* (2000), adults are able to tolerate silty or muddy conditions for unknown lengths of time, but juveniles are never found in this type of habitat. Nevertheless, and contra to Hastie *et al.*, the size range of mussel shells (54mm-110mm) suggests that successful recruitment has been occurring at the site over several decades, but perhaps not very recently. Although exceptional, these findings indicate that *M. margaritifera* (including juveniles) can sometimes survive in completely atypical physical microhabitat conditions. Perhaps the mussels in Shetland have been isolated for so long that they have specially adapted to the unusual conditions in lower section and side channel of Burn A.

Freshwater pearl mussels have a short parasitic larval phase on the gills of suitable host fish. The larvae (glochidia) of *M. margaritifera* are host specific and, as far as is known, can only complete their development on Atlantic salmon *Salmo salar* (L.) or sea trout and brown trout *Salmo trutta* (L.), usually 0+ fish, i.e. fry in their first year after hatching (Young and Williams 1984; Hastie and Young 2001). Very little is known about the mussel-host relationship, but the long term survival of mussel populations clearly depends upon host availability (Hastie and Cosgrove 2001). The presence of host salmonid fry in the fen side channel would clearly allow glochidia to develop, but what is not clear, is what substrate would be used by the young mussels when they drop off the fish at settlement.

Young mussels normally require clean fast flowing water running over mixed stable sands and gravel – not an ephemeral dry peat channel, with occasional wet seepages covered in vegetation. The local crofter whose land the fen is on, said that the dry side channel filled up with water during the autumn and winter (*pers comm.*). These increased flows would undoubtedly be important for the mussels and host fish, but whether these additional seasonal flows provide suitable conditions or a mechanism for juvenile recruitment and dispersal is purely speculative.

CONSERVATION IMPLICATIONS

The distribution of mussels in the Burn A catchment is highly localised and concentrated in the lowest section of the main stem and the side channel. This makes the mussels vulnerable to any changes in the management of the fen area, and especially to changes in the hydrology of either the main burn stem or the fen habitat. River engineering activities such as dredging are known to particularly badly affect freshwater pearl mussels by directly causing significant mortality and indirectly removing suitable substrate (Cosgrove and Hastie 2001) and these activities have been taken place in the main stem of the burn over the last decade. It is equally possible that destructive pearl fishing, which is also known to have taken place, could have removed almost all the mussels from the main channel. Such a short, narrow and shallow site would be particularly vulnerable to the removal of mussels and the 'undiscovered' population hidden in the fen habitat may have been an isolated refuge population that has slowly began to recolonise the very lowest reaches of the main stem of Burn A.

The presence of juvenile mussels, but lack of very recent recruitment gives some cause for concern, but this could easily be explained by low sample sizes and/or sampling bias due to the practical difficulties associated with surveying in the peat channel. Hastie and Cosgrove (2002) showed that the majority of juvenile mussels are missed even by experienced surveyors when undertaking stream-based searches under optimal search conditions and that the lack of juveniles observed in some otherwise 'healthy' *M. margaritifera* populations may be explained by this sampling bias. Large numbers of mussels (more than the 30 measured in this survey) are normally required to determine if recent recruitment has occurred or not. This was simply not possible to ascertain in the dark peat channels underneath the rank fen habitat.

New drainage in the area might disrupt the hydrology of the fen and alter the already small summer flows and seepages in the side channel. Although, ten live mussels were detected in the recently dredged section of the main stem, it is likely that recent drainage (carried out in 2001 – Anon *pers comm.*) would have caused significant mortality to mussels in this section. It is likely that historical drainage and destructive pearl fishing have been responsible for the lack of mussels on the apparently suitable section of the main stem. It is probably no coincidence that the older dredged sections of the main stem further upstream did not contain mussels (dredged as most recently as c1996 - Anon *pers comm.*). There are plenty of potential host fish (small brown trout) in the main stem of the burn and the side channel and, given time, there is no obvious reason why the mussels could not eventually recolonise the upper dredged sections of the main stem.

Unfortunately, the threat of illegal pearl fishing destroying this unique population is considered high. On the Scottish Western Isles, where a few pearl mussel populations remain, destructive and illegal pearl fishing has taken place since *M. margaritifera* was completely protected by law (*pers obs.*) and the suspicion is that local islanders, rather than outsiders were responsible. On Shetland, one local resident recounted how he had collected 100+ mussels from the main stem of Burn A to search for pearls 20-30 years ago – confirming their wider historical presence in the catchment. He found no pearls and did not collect any more mussels (Anon. *pers comm.*). Therefore, it is believed that the pearl fishing threat remains and so the name and location of the burn should remain confidential to safeguard the site.

Shetland does not have many apparently suitable burns and the five most suitable sites (using conventional descriptions of physical microhabitat preferences) were surveyed. The lack of success finding unknown mussel populations in these five burns, suggests that Burn A is probably the only Shetland *M. margaritifera* site. During the 1998 national survey, Cosgrove *et al.* (2000) identified 52 'functional' or 'viable' mussel rivers in Scotland and since then another five viable freshwater pearl mussel rivers have been discovered. The addition of the Shetland site means that Scotland holds at least 58 'viable' *M. margaritifera* populations, further consolidating its position as one of the global strongholds for this endangered species. However, the small Shetland population is highly unusual and defies conventional definitions of suitable physical microhabitat requirements for freshwater pearl mussels, and in that regard is unique and worthy of further study and conservation efforts.

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THREE NEW CORALLIOPHILINE SPECIES FROM SOUTH-WEST PACIFIC (NEOGASTROPODA: MURICIDAE: CORALLIOPHILINAE)

Sadao Kosuge[1] & Marco Oliverio[2]

Abstract *Three new coralliophiline species are described from stations sampled in deep waters of New Caledonia, and Fiji in the South West Pacific:* Coralliophila rhomboidea, Babelomurex virginiae *and* Mipus coriolisi. *All species are compared with the morphologically closest species of* Coralliophila, Babelomurex *and* Mipus.

Key words Coralliophila, Babelomurex, Mipus, *New Caledonia, south-west Pacific*

INTRODUCTION

A revision of the coralliophiline species of the Southwest Pacific is presently in progress on the material collected by the staff of the Muséum National d'Histoire Naturelle (MNHN, Paris) and Institut de Recherche pour le Développement (IRD, formerly ORSTOM, Nouméa) during the MUSORSTOM campaigns (more that 60 species from intertidal to 600 m). Some species were already recognised as undescribed during a preliminary screening of the material by the senior author. One of them has been described separately (Kosuge & Oliverio, 2001). Preliminary to the main regional monograph, we present here the description of other three new species.

Supraspecific systematics of the Coralliophilinae needs a re-examination by refined morphology and the support of markers independent of morphology. As a mere example, the allegedly monophyletic and commonly considered as a well defined "genus" *Coralliophila* H. & A. Adams, 1853 has been shown to be clearly polyphyletic (Oliverio, Cervelli & Mariottini, 2002). Particularly, the type species *C. neritoidea* (Lamarck, 1816) is more closely related to the spiny *Babelomurex* and *Latiaxis* than e.g. to *C. meyendorffii* (Calcara, 1845), *C. panormitana* (Monterosato, 1869), *C. brevis* (Blainville, 1832). We have thus adopted herein a conservative systematics, including the new species into three "genera" conceived as in the traditional taxonomy (e.g.: Kosuge & Suzuki, 1985): *Babelomurex* Coen, 1922, *Coralliophila* and *Mipus* De Gregorio, 1885. The new species have been collected so far only in a relatively restricted area in the Southwest Pacific. They are not known from the intensively explored Philippines.

Details on the sampling area and the relevant stations are reported by Richer de Forges (1990, 1993) and Richer de Forges & Chevillon (1996).

As suprageneric systematics is concerned, the anatomy of *Coralliophila* and related groups (e.g. *Babelomurex, Leptoconchus* Rüppell, 1834 etc...) is commonly assumed to indicate a separation at the family level from the rest of muricids (Kantor, 1995; Richter & Luque, 2002). Recent molecular data strongly contrast this view (Oliverio & Mariottini, 2001; Oliverio, Cervelli & Mariottini, 2002) and indicate that they must be included in a subfamily Coralliophilinae of the Muricidae: the deviating anatomy is probably correlated with their specialised mode of feeding on cnidarians.

In the next section, the notations lv (live collected) and dd (dead) are used for the specimens.

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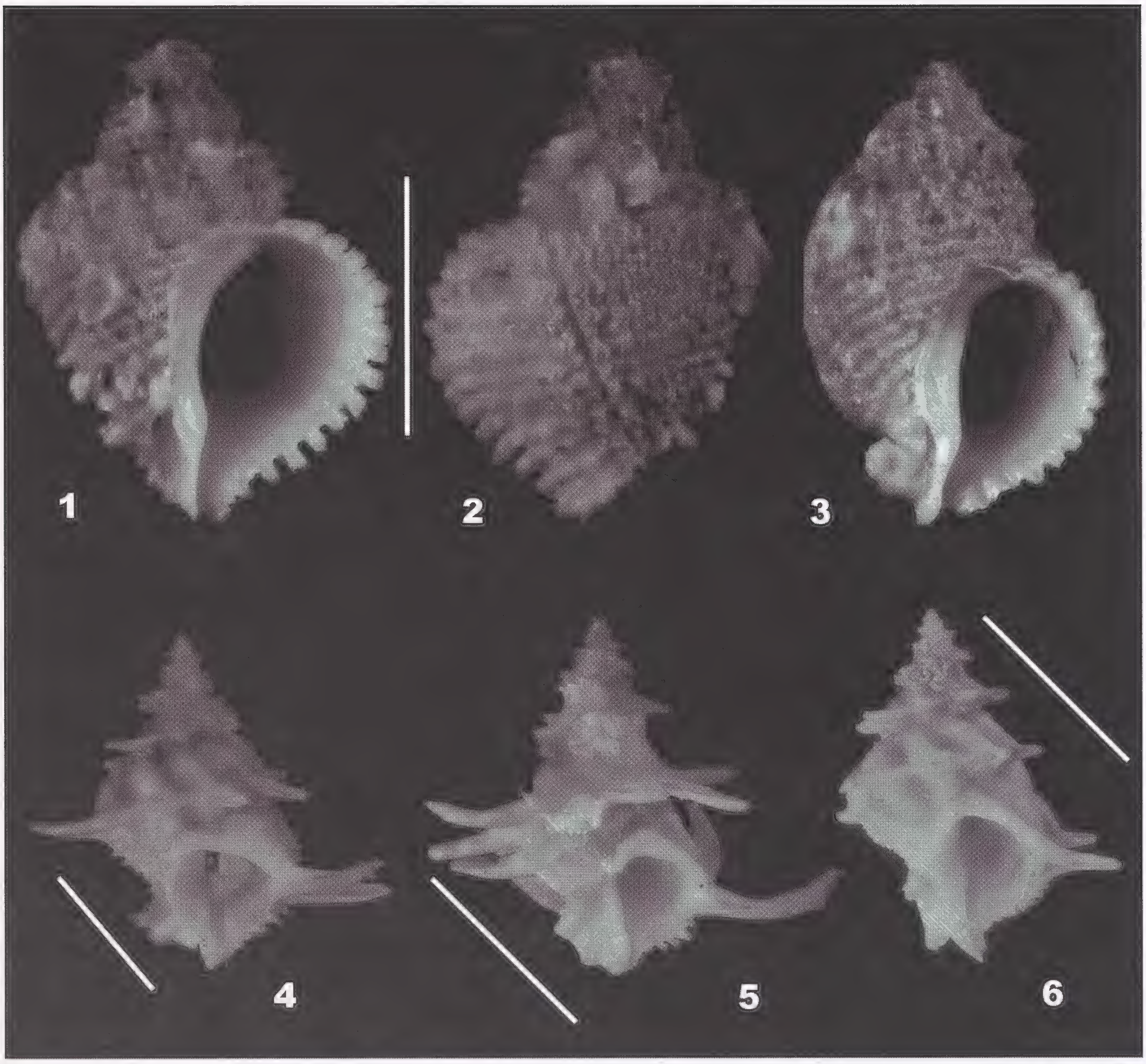
[1] Institute of Malacology of Tokyo, 6-36, Midoricho 3 chome, Tanashi City, Tokyo, Japan

[2] Dipartimento di Biologia Animale e dell'Uomo, "La Sapienza" Rome University, Viale dell'Università 32, I-00185 Roma, Italy. E-mail: marco.oliverio@uniroma1.it



Figs 1-3 *Coralliophila rhomboidea* n. sp.: **1, 2** holotype (SMIB 3 stn DW 29), 22°47′S, 167°12′E, 405 m, (MNHN). **3** paratype (SMIB 3 stn DW 29), 22°47′S, 167°12′E, 405 m, (MNHN).
Figs 4-6 *Babelomurex virginiae* n. sp.: **4** holotype (SMIB 3 stn DW 18), 23°42′S, 167°59′E, 338 m, (MNHN). **5** paratype (SMIB 5 stn DW 71), 23°41′S, 168°01′E, 265 m, (MNHN). **6** paratype (SMIB 5 stn DW 77), 23°41′S, 168°01′E, 270 m, (MNHN). Scale bars: 10 mm

Systematic Description

Superfamily Muricoidea Rafinesque, 1815
Family Muricidae Rafinesque, 1815
Subfamily Coralliophilinae Chenu, 1859

Genus *Coralliophila* H. & A. Adams, 1853
Type species: *Fusus neritoideus* Lamarck, 1816

Coralliophila rhomboidea n. sp.
Figs 1-3

Holotype A specimen from South of New Caledonia (SMIB 3 stn DW 29), MNHN (lv).

Paratype **South of New Caledonia:** one specimen (lv, MNHN) from the type locality (SMIB 3 stn DW 29, South of New Caledonia).

Type locality The area of stn DW 29, 22°47′S, 167°12′E, 405 m depth, South of New Caledonia, South West Pacific.

Distribution *Coralliophila rhomboidea* n. sp. is known only from the type locality.

Description Shell of medium size for the genus, height 19.9 mm and width 14.8 mm in the holotype, solid, rhomboidal in shape. Protoconch eroded and partly missing in the two available specimens.

Teleoconch of 5 whorls in the holotype. Spire relatively high, conical, with convex sides, constricted at the incised suture. Body whorl inflated, exceeding two thirds of the total shell height, gently angulated at the shoulder, then with straight basal sides. Aperture large, oval. Outer lip thin, simple, finely crenulated, internally lirate. Inner lip gently arcuate, callous. Siphonal canal short, broadly open; umbilical area narrow with low narrow fasciole, umbilical chink narrow. Sculpture on the teleoconch whorls consisting of closely set broad spiral cords with minute, densely packed imbricate scales. Twelve primary and 5 secondary cords on the body whorl (a total of 6 visible in the penultimate whorl). Ground colour ivory white, inside the aperture bright white. Operculum chestnut brown, oval in shape with latero-terminal nucleus.

Derivation of name The epithet *rhomboidea* (rhomboid in shape) refers to the characteristic outline of the shell.

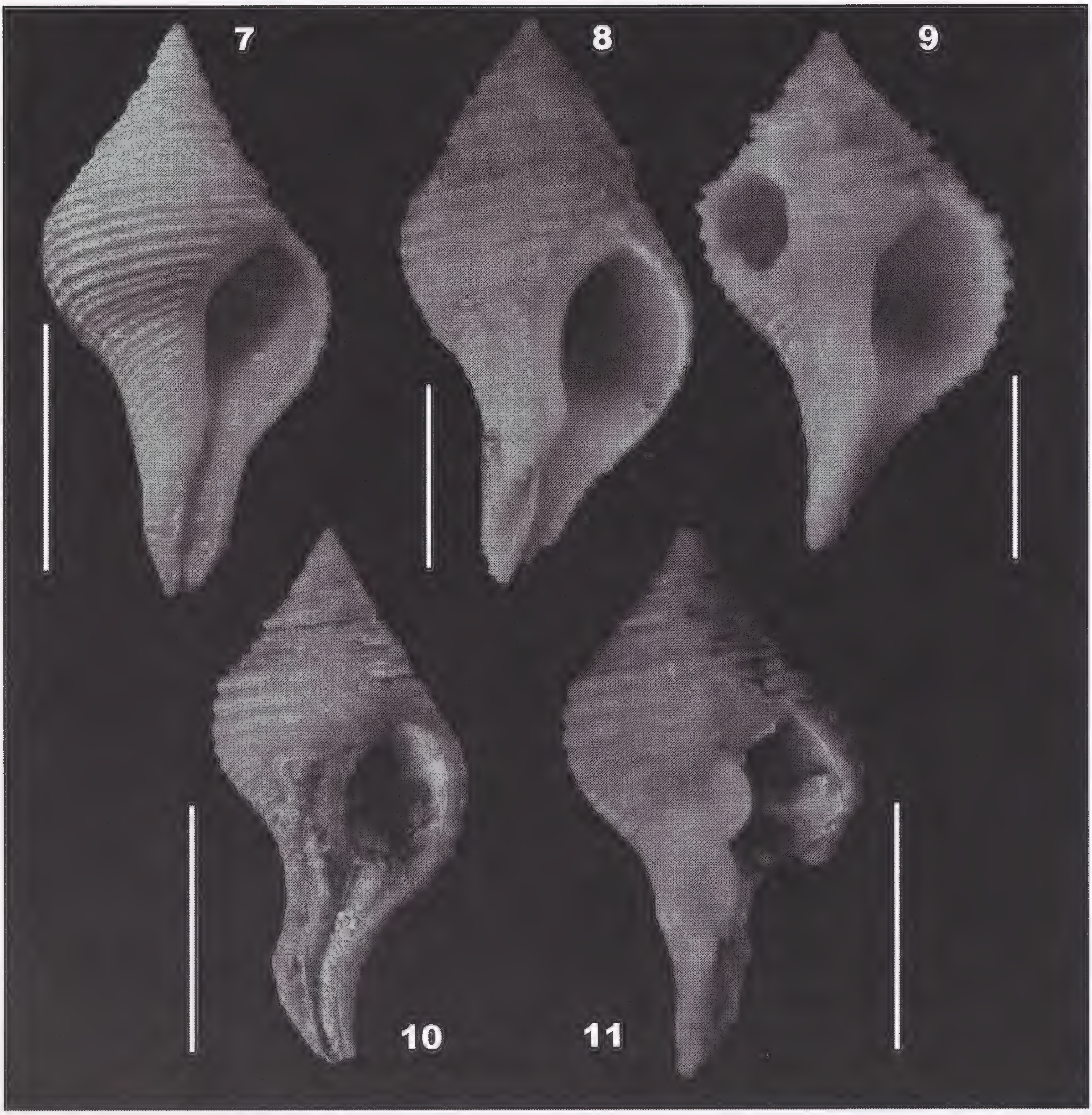
Remarks *Coralliophila rhomboidea* n. sp. is diagnosed, among the species with embricated sculpture, by its large and expanded body whorl. *C. pulchella* (A. Adams, 1854) and *C. carolae* D'Attilio & Myers, 1984, from the Indo-Pacific, and *C. brevis* (Blainville, 1832) and *C. kaofitorum* Vega, Vega & Luque, 2002, from the NE Atlantic region, show some similarities with the new species. They differ in the less rounded spire whorl, the more irregular growth of the shell in the adult, the more spaced spiral sculpture. *C. squamulosa* (Reeve, 1846), has a somehow similar appearance but differs in the much lower spire and the whitish-lilac colouration (violet in the aperture). *C. bulbiformis* (Conrad, 1837), differs in the straighter whorls, the larger size (up to 30 mm), the colouration of the shell and especially inside the aperture (pink-lilac). *C. inflata* (Dunker, 1847) has a more slender shell, a longer siphonal canal, and a finer sculpture. *C. abnormis* (Smith, 1878), *C. amirantium* Smith, 1884 and *C. persica* Melvill, 1897, have a higher spire, a smaller aperture and a finer sculpture.

Genus *Babelomurex* Coen, 1922
Type species: *Fusus babelis* Requien, 1848

***Babelomurex virginiae* n. sp.**
Figs 5-6

Holotype A specimen from South New Caledonia (SMIB 3 stn DW 18), MNHN (lv).

Paratypes **South of New Caledonia:** (SMIB 3 stn DW 8), 24°45′S, 168°08′E, 233 m, 1 dd (MNHN); (SMIB 3 stn DW 41), 24°44′S, 168°09′E, 230-235 m, 1 dd (MNHN); (SMIB 4 stn DW 44), 24°46′S, 168°08′E, 270-300 m, 1 dd (MNHN); (SMIB 5 stn DW 75), 23°41′S, 168°01′E, 270 m, 1 dd (MNHN); (SMIB 5 stn DW 77), 23°41′S, 168°01′E, 270 m, 2 dd (MNHN); (CHALCAL 2 stn DW 71), 24°42′S, 168°10′E, 230 m, 1 dd (MNHN); (SMIB 8



Figs 7-11 *Mipus coriolisi* n. sp.: **7** holotype (MUSORSTOM 5: stn 341), 19°46'S, 158°43'E, 630-620 m, (MNHN). **8** paratype (BATHUS 4 stn CP 911), 18°58'S, 163°09'E, 558-566 m, (MNHN). **9, 10** paratypes (BATHUS 2 stn DW 721), 22°54'S, 167°17'E, 525-547 m, (MNHN). **11** paratype (BATHUS 4 stn DW 920), 18°45'S, 163°17'E, 610-620 m, (MNHN). Scale bars: 10 mm (7-9), 5 mm (10, 11).

stns DW154 to DW159), 24°46'S, 168°08'E, 235-300 m, 1 dd (MNHN); (LITHIST stn CP 17), 23°41'S, 168°01'E, 247-281, 1dd (MNHN).

Other material examined **Loyalty Ridge**: (SMIB 5 stn DW 93), 22°20'S, 168°42'E, 255 m, 1 dd (MNHN). **Hunter & Matthews Vulcans:** (VOLSMAR stn DW 17), 22°23'S, 171°41'E, 260-300 m, 1 dd (MNHN). **Fiji**: (BORDAU 1 stn DW 1469), 19°40'S, 178°10'W, 314-377 m, 2 dd (MNHN)

Type locality The area of Stn DW 18, 23°42'S, 167°59'E, 338 m depth, South of New Caledonia, South West Pacific.

Distribution *Babelomurex virginiae* n. sp. is known from southern New Caledonia and the area between Loyalty Ridge and Fiji.

Description Shell of small size for the genus, height 16-25 mm and width 15-25 mm in the largest adults (height 23.5 mm, width 23.3 mm in the holotype), rather solid, rhomboidal in shape. Protoconch eroded in the available material.

Teleoconch of 5-6 (5 in the holotype) whorls in the largest shells, the last one about 70% of total height. Spire high, conical, with flat or slightly convex sides well angulated at the periphery. Suture incised. Body whorl two third of the total shell height, constricted at the base. Aperture moderately large (8.3 mm high and 5.5 mm wide in the holotype), semicircular. Outer lip with finely crenulated edge, internally lirate, angulated at the shoulder, usually continuous in correspondence of the peripheral spines; inner lip almost straight, extending into a sharply detached callus. Siphonal canal moderately long, sharply curved dorsally and usually gently curved rightwards; umbilicus deep and narrowly perforated. Teleoconch axial sculpture on the last whorl of 7-11 prosocline axial ribs (8 in the holotype), and 7-9 on the first whorls. A single row of scabrous spines at about half the height of the spire (suprasutural on the first whorls), each corresponding to one axial rib on the body whorl, and consisting of long and narrow folded laminae, with the open side toward the aperture. Spiral sculpture of 22-25 densely packed spiral cords minutely scabrous due to finely embricated lamellae: 10 cords above, 7-10 (10 in the holotype) below the spine row on the last whorl, and 5 on the siphonal canal; fasciole bearing sharp scaly projections. Microsculpture of irregular growth lines and of very minute spiral threads. Ground colour whitish to brownish, usually with darker interspaces.

Derivation of name The new species is dedicated to Virginie Héros, for her invaluable cooperation during all phases of the investigation on the SW Pacific marine fauna.

Remarks *Babelomurex virginiae* is similar to the very variable *B. spinosus* (Hirase, 1908) in its shell shape and spiny projections, but it differs by its single row of spines and the more scabrous spiral cords covering the entire body whorl surface. *B. fruticosus* (Kosuge, 1979) is also similar but it is devoid of the scabrous spiral sculpture, has always an additional row of spines below the peripheral one, and has a more slender spire. The species in the group of *B. diadema* (A. Adams, 1854) differ from *B. virginiae* n. sp. in the presence of additional rows of spines and in their broader peripheral spines. *B. armatus* (Sowerby, 1912) has a single peripheral row of spines and a scabrous spiral sculpture covering the entire shell surface. It differs from the new species in the larger size, the lower spire, the wider aperture, the spines usually more posteriorly oriented, and the axial ribs (when present) orthocline.

Genus *Mipus* de Gregorio, 1885.
Type species (o.d.): *Trophon gyratus* Hinds, 1884

***Mipus coriolisi* n. sp.**
Figs 7-11

Holotype A shell from Chesterfield (MUSORSTOM 5 stn 341), MNHN (dd).

Paratypes **New Caledonia**: (BATHUS 2 stn DW 721), 22°54'S, 167°17'E, 525-547 m, 2 dd (MNHN); (BATHUS 4 stn CP 911), 18°58'S, 163°09'E, 558-566 m, 1 dd (MNHN); (BATHUS 4 stn DW 920), 18°45'S, 163°17'E, 610-620 m, 1 dd (MNHN).

Type locality The area of stn 341, 19°46'S, 158°43'E, 630-620 m depth, Chesterfield, Coral Sea, South West Pacific.

Distribution *Mipus coriolisi* s. sp. is known only from a restricted area in the Coral Sea, North of New Caledonia. No living specimens have been so far collected.

Description Shell of large size for the genus, height 18-23 mm in the largest adults (height 22.7 mm, width 11.7 mm in the holotype), rather thick and solid, spindle like in the outline. Protoconch missing in the available material.

Teleoconch of up to 6 whorls (5+ in the holotype). Spire high, conical, with flat sides, suture canaliculated, not incised. Body whorl large, very gently rounded at the shoulder and concave below, moderately constricted at the base. Aperture large, oval. Outer lip broken in all shells. Inner lip sharply bent, callous. Siphonal canal long, broadly open, straight or curved. Umbilicus closed with narrow, low siphonal fasciole.

Sculpture of the teleoconch whorls consisting of spiral cords covered by minute, densely packed imbricate scales. Two primary cords visible on the first two teleoconch whorl; an intermediate cord gradually appearing on each interspace, resulting in a total of five spiral cords visible on the penultimate whorl. Last whorl bearing 18-22 (22 in the holotype) primary cords and 5-12 (7 in the holotype) irregularly set secondary cords.

External colour ivory-whitish; inside the aperture and parietal callus bright white.

Derivation of name The epithet *coriolisi* refers to the R/V "Coriolis" that was employed for the MUSORSTOM 5 campaign in the Coral Sea.

Remarks The new species is somewhat similar to *Mipus matsumotoi* Kosuge, 1985 but it differs in the lower spire and the spindle-like shell shape. *Mipus sugitanii* Kosuge, 1985 is also similar but has constantly a keeled periphery of the whorls and a higher spire. *M. gyratus* (Hinds, 1844), *M. intermedius* Kosuge, 1985 and *M. eugeniae* (Bernardi, 1853) are larger in size, have more convex whorls with the suture more incised.

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PRESERVATION OF SPECIES DIVERSITY AND ABUNDANCES IN PACIFIC ISLAND LAND SNAIL DEATH ASSEMBLAGES

REBECCA J. RUNDELL[1] & ROBERT H. COWIE[2]

Abstract *Data from 11 land snail surveys undertaken on the islands of the Pacific (Hawaii, American Samoa, Palau) are analyzed in order to ascertain the proportions of species represented in the death assemblage alone or the live assemblage alone, and whether the abundances of the individual species in the two assemblages are correlated. The percentage of species collected only as dead shells ranged from 13 % to 52 % (mean = 31.6 %), while that found only in the live assemblage was considerably lower (mean = 10.2 %). At nine of the 11 localities the rank abundances of species in the dead and live assemblages were significantly correlated, although in most cases the correlation was not strong. Taphonomic differences among species and localities as well as sample sizes may weaken the correlations, but real change in abundances of certain species may also be involved.*

Key words *Mollusca, land snails, Pacific islands, biodiversity, taphonomy.*

INTRODUCTION

Pacific island land snail faunas are among the most diverse in the world, in terms of both species richness and ecological and morphological diversity (e.g. Cowie, 1996a, b). Huge evolutionary radiations of endemic species have attracted the attention of biologists for many years (e.g. Garrett, 1884; Gulick, 1905; Pilsbry & Cooke, 1912-1914; Solem, 1983; Cowie *et al.*, 1995a; Cowie 1998a). These faunas, however, are highly threatened by human-mediated changes in their environment, including habitat destruction and the introduction of alien species (including snail predators introduced for biological control), and have probably suffered as a result of over-collecting (Hadfield, 1986; Hadfield *et al.*, 1993; Cowie, 1992; Cowie & Cook, 2001; Cowie & Robinson, 2003). Their evolutionary uniqueness and precarious conservation status make them potentially important subjects for research in both evolutionary and conservation biology.

Land snail diversity surveys are the most fundamental part of such research, particularly because many Pacific island land snail faunas are still poorly known (Cowie 1996a; Cowie & Rundell, 2002; Cowie *et al.*, 2002). Surveys are vital to future conservation management, as they constitute the baseline from which to track changes in species distribution and abundance, including extinctions.

Live-dead assemblage agreement studies, which investigate whether the relative abundances present in the live assemblage are reflected in the death assemblage, have been an important means of assessing whether researchers can rely on information gathered from only the death assemblage, such as that gathered from the fossil record (Johnson, 1965; Kidwell, 2001a). Recent studies of marine invertebrate assemblages have shown that in some cases, but not all, there is high fidelity between life and death assemblage abundances (Kidwell 2001a, b; Warwick & Light, 2002).

It is widely accepted that tropical terrestrial faunas do not preserve well and are seldom represented in the fossil record, perhaps because of the often acidic rainforest soils and the consequent rapid decomposition (Tappen, 1994). Dry forest death assemblages may also be subject to the harsh weathering forces of wind and temperature and moisture

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[1] Committee on Evolutionary Biology, University of Chicago, 1025 E. 57th Street, Culver 402, Chicago, Illinois 60637, USA. rundell@uchicago.edu.

[2] Center for Conservation Research and Training, Pacific Biomedical Research Center, University of Hawaii, 3050 Maile Way, Gilmore 408, Honolulu, Hawaii 96822, USA. cowie@hawaii.edu.

fluctuations (Behrensmeyer, 1978). However, land snail fossils and "subfossils" (old-looking shells often of unknown age) are often found on Pacific islands in large accumulations (Cooke & Kondo, 1952; Christensen & Kirch, 1981, 1986, Dixon *et al.*, 1997), indicating that some species' shells can indeed be preserved for extended periods. Furthermore, dead shells are always encountered and often collected along with live snails during surveys and are assumed to provide information on current and past species' distributions and abundances. Unlike many terrestrial invertebrates, land snails often leave behind significant, identifiable (generally to species-level) traces of their existence (their shells) for many years, making them potentially important indicators of invertebrate community change.

In this study, using 11 live-dead land snail datasets derived from surveys undertaken in Hawaii, American Samoa and Palau, we assess the following.

1) How much of the total species diversity at each site is present only in the death assemblage? If a species is recorded only in the death assemblage, it may be too rare to have been recorded in the live collections or may be locally extinct (both have ecological and/or conservation implications) (e.g. Preece, 1995, 1998; Bouchet & Abdou, 2001). The reverse may also be true, that some species are only collected as live specimens.

2) How well do relative abundances between live and dead collections match at each site? In areas where live snails are no longer present, it may be important to assess the relative abundances of the species that once existed there, as indicated by the death assemblage. Within areas that do still have live snails, changes in relative abundances among species are important from both ecological and conservation perspectives (e.g. Christensen & Kirch, 1986), and examination of the death assemblage may be a good way to deduce these changes.

3) How well do rank abundances in recently dead and long dead assemblages agree? Although it is difficult to assess how long a dead shell has been present on the ground, comparisons between more recently dead-looking shells (with periostracum and pigmentation intact) and long dead-looking shells (no periostracum, bleached white, possibly cracked) may show that either changes in community composition were quite recent (if dead and long dead assemblages agree more than live-dead assemblages in rank order abundances), or at least that species do not drop out of the potentially fossilizable shell assemblage right away, and species abundances are captured even in the long dead assemblage.

METHODS

Eleven datasets from a range of habitat types and islands (Table 1), derived from surveys that were undertaken between 1992 and 2001 and incorporated 455 sampling stations, were selected for analysis. The raw data are available in the reports cited in Table 1 and from the Bishop Museum (Honolulu) Malacology Collection database. Collection methodologies have been explained in detail by Cowie (2001a). Briefly, timed sampling in the field rather than collection of litter/soil samples was the approach adopted, since this is the most efficient way to obtain large numbers of samples and large geographic coverage (see Emberton *et al.*, 1996). Such a methodology under-samples smaller snails but this does not influence the present analysis because the same methodology was used in all the surveys.

Records were compiled from the survey reports, each consisting of survey station, species and the number of live and dead specimens collected (in some cases recently dead and long dead shells were distinguished). Slugs were omitted because, lacking a shell, they were not readily identified in the death assemblage. Total numbers of live

TABLE 1

Survey locations, number of sampling stations, habitat types and data sources.

Island	Survey locality	No. of stations	Habitat Type	Data Source
Hawaiian Islands				
Hawaii	Waiakea, South Hilo	82	rainforest	Cowie *et al.*, 1999a; Howarth *et al.*, 1999
Hawaii	Saddle Road	28	mostly dry forest	Evenhuis *et al.*, 1996
Hawaii	Pohakuloa Training Area	59	dry forest	Cowie & Nishida, 1993
Hawaii	North Kohala	16	wet, highly disturbed	Cowie *et al.*, 1999b
Oahu	Waahila Ridge	33	dry forest	Cowie *et al.*, 1999c, d
American Samoa				
Tutuila	National Park of American Samoa	112	rainforest	Cowie & Cook, 1999
Tau	entire island	51	wet, various	Cowie & Cook, 1999
Ofu	entire island	18	wet, various	Cowie & Cook, 1999
Olosega	entire island	14	wet, various	Cowie *et al.*, 2002, unpublished
Aunuu	entire island	10	wet, various	Cowie & Rundell, 2002, unpublished
Palau				
Babeldaob	entire island	32	wet, various	Cowie *et al.*, 1996

and dead individuals of each species were determined for each of the surveys, combining sampling stations within each survey because numbers of individuals at each station were too low to permit valid statistical analysis. Combining stations within surveys was legitimate because environments did not vary greatly among most stations within each of the survey localities and because taphonomic differences among the stations were not being assessed.

Percentages of land snail species found only in the live and dead assemblages in each survey were calculated. For each survey locality, species were ranked according to their abundances in the live assemblage, the dead assemblage, and the long dead assemblage. Spearman rank correlation coefficients (Glantz, 1992) were then calculated for the live vs. dead (including long dead) and dead vs. long dead abundances.

RESULTS

The species collected in each of the surveys are shown in Table 2 (at end of paper) (excluding slugs). Summary data are given in Table 3. The percentage of species collected only as dead shells ranged from 13 % (Waiakea, Hawaii) to 52 % (Ofu, American Samoa) (mean = 31.6 %). Dry forests (Saddle Road, Pohakuloa Training Area, Waahila Ridge) generally had the highest proportion of species represented only in the

TABLE 3

Summary data for each survey: total number of species; percentages of species found only in the dead and live assemblages; and number of specimens collected live, dead and long dead (long dead data only available for Saddle Road and Pohakuloa Training Area).

Survey locality	**Total species**	**% dead only**	**% live only**	**Number of specimens**		
				live	**dead**	**long dead**
Hawaiian Islands						
Hawaii: Waiakea, South Hilo	15	13	33	1073	509	---
Hawaii: Saddle Road	15	47	7	70	643	757
Hawaii: Pohakuloa Training Area	16	40	0	263	4458	7145
Hawaii: North Kohala	6	33	0	33	103	---
Oahu: Waahila Ridge	21	43	5	56	1040	---
American Samoa						
Tutuila: National Park	28	17	11	7168	1360	---
Tau	22	18	14	1356	562	---
Ofu	27	52	11	568	818	---
Olosega	21	29	10	340	344	---
Aunuu	15	27	7	272	141	---
Palau						
Babeldaob	27	26	15	115	234	---

death assemblage, while the two rainforest sites (Waiakea, Tutuila) had the fewest. In all but one case (Waiakea) the percentage of species found only in the live assemblage (mean = 10.2 %; excluding Waiakea, mean = 7.9 %) was considerably lower than that found only in the death assemblage (mean = 31.4 %; excluding Waiakea, mean = 33.2 %), but there was no clear trend related to habitat type.

At nine of the 11 localities the rank abundances of species in the live and dead assemblages were statistically significantly correlated (Table 4). They were not significantly correlated at North Kohala (Hawaiian Islands) and Ofu (American Samoa). At the two localities for which the death assemblage was broken down into dead and long dead shells, the rank abundances of species in the dead and long dead assemblages were also significantly correlated (Saddle Road, Hawaii, Spearman rank correlation coefficient $r_S = 0.815$, $p<0.001$; Pohakuloa Training Area, Hawaii, $r_S = 0.938$, $p<0.001$).

DISCUSSION

SPECIES DIVERSITY CAPTURED BY LIVE AND DEAD ASSEMBLAGES

A greater percentage of total species richness was discovered in the death assemblages than in the live assemblages. In two of the 11 surveys (Pohakuloa Training Area, North Kohala) all species were represented in the death assemblage. Nevertheless, for the most part, neither the death assemblage nor the live assemblage captured overall species richness. In the two dry forest surveys (Pohakuloa Training Area, Waahila ridge) the proportion of specimens collected dead was much larger than in the other surveys; live snails are simply harder to find in such habitats because they tend only to be active during times of increased humidity, at other times secreting themselves deep in crevices and other harder to sample microhabitats. A species' absence from the live assemblage may reflect its local extinction, although it is also possible that more prolonged survey effort, and perhaps litter and soil sampling, may have increased the proportion of species represented in the live assemblage at these localities, and this is probably true generally (Kidwell, 2001a). Local extinction may well be the case for *Palline* sp. cf. *notera* on Babelaob (Palau), as most charopids appear to have declined severely in the Pacific (Solem, 1983). It may also be the case for *Allopeas gracile* on Olosega (American Samoa). This species, introduced widely by Pacific islanders prior to exploration of the Pacific by westerners (Christensen & Kirch, 1981, 1986; Kirch, 1983), was once extremely abundant (Pilsbry, 1906-1907) but is now rarely found alive (Cowie, 2001a, b).

Presence only in the live assemblage is more difficult to explain. In the wettest habitats (most notably Waiakea) dead shells may break down more quickly than in very dry habitats such as Pohakuloa Training Area and Waahila Ridge, reducing the likelihood of their being recorded in the death assemblages. A significant proportion of species only found alive at some localities, or at least found in much greater abundance in the live assemblages, are tree snails (e.g., *Pleuropoma beryllina*, *Diastole schmeltziana*). Why their shells are not well represented in the death assemblages (sampled on the ground) is not clear, although at least in the case of *D. schmeltziana* its shell is thin and probably disintegrates rapidly after death.

Given limited resources for biodiversity surveys of this kind, collecting data from both the live and dead assemblages is the most pragmatic strategy for capturing total species diversity. It may be particularly important for detecting recently established alien species. For example, in two of the datasets (North Kohala, Saddle Road), *Euglandina rosea*, a voracious introduced predator of other snails, was collected only from the death assemblage, although it is almost certainly part of the live assemblage. Even if such species represent a small percentage of the overall species diversity, it is important to recognize their presence as early as possible, in order to adapt management practices to minimize their spread (Cowie, 1997). Although collecting both sets of data is necessary, keeping them separate is important for detecting possible local extinction (see above).

SPECIES RANK ORDER ABUNDANCE CORRELATIONS

In all but two localities, the rank order abundances of species in the live and dead assemblages were correlated. In general, therefore, the death assemblage reflects the species composition in the live assemblage. This is important because at most localities a proportion of the species was missing from the live assemblage, especially in dry forest localities (see above). We can infer that probably these species that were absent in the sampled live assemblage were indeed present in the real live assemblage but were not found by the sampling methods adopted.

At two localities the rank order abundances in the live and death assemblages were not correlated. In one of these cases (North Kohala) this may be explained by the low number of species (six) and hence lack of statistical power. The other instance (Ofu) is

TABLE 4
Spearman rank correlations (r_S) between species abundances in the live and dead assemblages. p-values from Glantz (1992).

Survey locality	Number of species	r_S	p
Hawaiian Islands			
Hawaii: Waiakea, South Hilo	15	0.637	<0.02
Hawaii: North Kohala	6	0.653	n.s.
Hawaii: Pohakuloa Training Area	16	0.582	0.02
Hawaii: Saddle Road	15	0.559	<0.05
Oahu: Waahila Ridge	21	0.617	<0.005
American Samoa			
Tutuila: National Park	28	0.465	<0.02
Tau	22	0.508	<0.02
Ofu	27	0.210	n.s.
Olosega	21	0.466	<0.05
Aunuu	15	0.569	<0.05
Palau			
Babeldaob	27	0.427	<0.05

not easily explained.

However, although most localities exhibited a correlation between the live and death assemblages, in few cases was this a strong correlation. Many variables can influence a species being represented in both sampled assemblages, including different rates of breakdown of shells, different relative visibility (and hence likelihood of being sampled) in the live and death assemblages, rarity (resulting in sample sizes for some species being very small and the assemblage being dominated by a few very abundant species), and real changes in abundance over time.

We have no knowledge of relative rates of breakdown of different species' shells in different environments. We do not know how old the death assemblages are, nor the difference between the dead and long-dead assemblages in the two cases in which we have those data. Different species almost certainly degrade at different rates, and individual shells of a single species will also degrade at different rates depending on the microhabitat in which they find themselves (Carter, 1990). To take full advantage of land snail death assemblages for evolutionary and conservation studies, greater efforts to understand taphonomic processes must be made (cf. Bickart, 1984).

There may indeed have been real changes in community composition over time. Evidence from several species suggests that this might be the case (Cowie, 2001b). For example, in our study *Succinea konaensis* was collected at both Pohakuloa Training Area and Saddle Road (Hawaiian Islands), but out of 2343 specimens found, only 11 were alive. This species' historical range extends across most of the western side of the Island of Hawaii, an area of approximately 455 km^2 (Rundell, 2001). Although dead shells of *S. konaensis* are abundant throughout the historical range, it is difficult to find the species alive anywhere. Although some dry forest snails may have seasonal life histories resulting in their being active and readily found alive only at certain times of year, this cannot account for this scarcity of live *S. konaensis* in the surveys because the larger survey at least (Pohakuloa Training Area) took place over six occasions spread throughout an entire year. It is possible that *S. konaensis* is suffering a real decline even in the small parts of its original wide range where it is still extant. If this kind of change is taking place in only one or a few species, then the overall correlation would be weakened but would not necessarily disappear.

CONCLUSION

With a better understanding of taphonomy, comparisons such as these could be used to analyze community change over time, which for most Pacific island land snail faunas has considerable conservation implications. Such studies are possible only for organisms that leave a substantial record of their presence after death, which among terrestrial invertebrates means essentially only the snails. Snails thus have the potential to be important indicators of relatively short term ecological change. Indeed, land snails already have been used to investigate change over a longer term archaeological time scale (Evans, 1972; Christensen & Kirch, 1981, 1986; David & Stanisic, 1991).

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TABLE 2
Species recorded at each survey locality.

Species	*Hawaiian Islands*					*American Samoa*					***Palau***
	Hawaii	**Hawaii**	**Hawaii**	**Hawaii**	**Oahu**	**Tutuila**	**Tau**	**Ofu**	**Olosega**	**Aunuu**	**Babeldoab**
	Waiakea	**Saddle Rd.**	**PTA**	**N. Kohala**	**Waahila**						
Helicinidae											
Orobophana musiva						+	+	+	+	+	
Pleuropoma beryllina						+	+		+		
Pleuropoma fulgora						+	+	+	+	+	
Pleuropoma n. sp.							+				
Sulfurina sturanii											+
Hydrocenidae											
Georissa sp.											+
Poteriidae											
Ostodes adjunctus						+					
Truncatellidae											
Truncatella guerinii							+	+	+	+	
Assimineidae											
Assiminea parvula						+	+	+		+	
Omphalotropis cheynei											+
Omphalotropis sp. A						+					
Omphalotropis sp. B							+				
Omphalotropis sp.								+		+	
Diplommatinidae											
Palaina sp. A											+
Palaina sp. B											+

Palaina sp. C										+
Palaina sp. D										+
Palaina sp. E										+
Palaina sp. F										+
Palaina sp. G										+
Pupinidae										
Pupina difficilis										+
Ellobiidae										
Melampus castaneus					+	+	+			
Melampus fasciatus					+	+	+	+	+	
Melampus ?luteus								+	+	
Pythia scarabaeus					+	+	+	+		+
Pythia sp.										+
Tralia costata						+	+			
Achatinellidae										
Auriculella armata	+									
Elasmias sp.					+	+	+			
Lamellidea oblonga				+						
Lamellidea pusilla							+	+	+	
Lamellidea sp.		+	+							
Tornatellaria smithi	+									
Tornatellides sp(p).			+							
Tornatellides sp. 1				+						
Tornatellides sp. 2				+						
Tornatellides sp. 3				+						

Tornatellides sp. A	+						
Tornatellides sp. B	+						
"tornatellinid" A		+					
"tornatellinid" B		+					
"tornatellinid" C		+					
"tornatellinid" D		+					
Amastridae							
Leptachatina lepida		+	+				
Leptachatina anceyana			+				
Leptachatina sp. A		+	+				
Leptachatina sp. B			+				
Leptachatina sp. C			+				
Pupillidae							
Gastrocopta servilis				+			
Nesopupa subcentralis		+	+				
Pronesopupa hystricella	+						
Pronesopupa sp.			+				
?*Pronesopupa* sp.					+		
Pupisoma orcula						+	
Partulidae							
Eua zebrina					+	+	
Samoana abbreviata					+		
Samoana conica					+		
Samoana thurstoni						+	+

Subulinidae										
Allopeas clavulinum	+		+	+	+	+	+	+		+
Allopeas gracile								+		
Beckianum beckianum				+						
Lamellaxis micra							+	+		
Opeas hannense				+			+	+		
Paropeas achatinaceum	+		+	+	+	+	+	+	+	+
Subulina octona				+	+	+	+	+	+	+
Ferussaciidae										
Cecilioides aperta				+						
Achatinidae										
Achatina fulica			+	+	+	+				+
Spiraxidae										
Euglandina rosea	+	+	+	+	+					
Streptaxidae										
Gonaxis kibweziensis				+	+					
Gonaxis quadrilateralis				+						
Gulella bicolor							+	+	+	+
Streptostele musaecola					+	+	+	+	+	
Charopidae										
Palline sp. cf. *notera*										+
Rhytididae										
Ouagapia gradate					+	+	+			
Succineidae										
Succinea caduca				+						

Succinea cepulla	+										
Succinea konaensis		+	+								
Succinea manuana							+	+	+		
Succinea modesta						+				+	
Succinea quadrata	+										
Succinea thaanumi	+										
Euconulidae											
Euconulus sp. cf. *gaetanoi*			+								
Euconulus thaanumi	+	+									
?*Euconulus* sp.					+						
Gastrodontidae											
Striatura sp. cf. *meniscus*		+	+								
?*Striatura* sp.		+	+								
Helicarionidae											
Diastole schmeltziana						+	+	+	+		
Diastole n. sp.							+	+	+		
Kororia palaensis											+
Liardetia doliolum				+							
Liardetia samoensis						+	+	+	+	+	
Ovachlamys fulgens	+			+	+	+				+	
Palaua babelthuapi											+
Palaua wilsoni											+
Palaua sp. cf. *ngarduaisi*											+
Palaua sp. cf. *straminea*											+
Palaua sp.											+
Philonesia sericans	+										

Philonesia sp.			+				
Videna sp. nov. A							+
Videna sp. nov. B							+
Vitrinidae							
Vitrina tenella		+	+				
Ariophantidae							
Parmarion martensi					+		
Zonitidae							
Hawaiia minuscula				+			
Nesovitrea hawaiiensis			+				
Oxychilus alliarius	+	+					
Trochomorpha apia					+		
Zonitoides arboreus				+			
Bradybaenidae							
Bradybaena similaris				+		+	

OCCURRENCE AND HABITAT OF *VERTIGO MODESTA ARCTICA* (GASTROPODA: VERTIGINIDAE) IN ANDORRA

Vertigo modesta arctica (Wallenberg, 1858) was found during a short visit to Andorra on 21-23 June 2001. There are two previous records of this species in the Pyrenees, from 'Col del Pam' at approximately 1900-2000 metres elevation several kilometres north of Font Romeu in Dept. Pyrénées-orientales, France (van Regteren Altena 1935[1]) and from 2000 metres elevation at Núria (Ripollès) in north-east Spain (Bech 1990[2], Bech & Ramirez 1990[3]). This predominantly boreal and arctic species, is otherwise known at temperate latitudes in Europe only from high altitudes in the Alps (Turner *et al.* 1998[4]) and Carpathians, from two localities in Scotland (Marriott & Marriott 1988[5], Kerney 1999[6]) and Scandinavia where it is almost entirely restricted to the mountains (von Proschwitz 2003[7]).

The Andorran site at which *V. modesta arctica* was found was at 2150 metres altitude south-east of Port d'Envalira at 42°32'N, 1°42'E. One live adult was obtained in the field by cutting and sieving vegetation. Despite prolonged sieving in the same small fen and of leaf litter and vegetation from beneath trees and small bushes nearby, no more were found in the field, although another six (five living, one dead) were obtained from bulk samples taken for later study.

All of the *V. modesta arctica* were obtained from a small area of herb-rich fen-grassland which had several small streams rising at calcareous spring-heads, on a slope of up to 20° facing west. The site was unshaded and lightly grazed by cattle. It was beneath the tree-line with patches of open woodland of *Pinus uncinata* on slopes close by. The height of the vegetation was variable with some parts obviously grazed; mean height 6 cm, maximum 22 cm. A plant list for the whole fen was compiled using DAFOR values to indicate the abundance of each species (D Dominant, A Abundant, F Frequent, O Occasional, R Rare; nomenclature follows Tutin *et al.* 1964-1980[8] for vascular plants, Blockeel & Long 1998[9] for bryophytes).

The vegetation was typical for a species-rich fen, vascular plants recorded as Frequent being *Carex panicea, C. viridula, Molinia caerulea, Nardus stricta, Pinguicula vulgaris, Potentilla erecta, Primula integrifolia,* and those recorded as Occasional being, Apiaceae sp., *Cardamine pratensis, Carex dioica, C. nigra, Eriophorum angustifolium, Festuca* sp., *Juncus filiformis, Leontodon autumnalis, Lotus corniculatus, Pedicularis kerneri, Phleum alpinum, Prunella vulgaris, Saxifraga aizoides, Selaginella selaginoides, Scirpus cespitosus* and *Trifolium repens*. Bryophytes were plentiful with Abundant/Dominant *Palustriella falcata* and Frequent *Philonotis calcarea* and *P. fontana*. Calciphiles were conspicuous in the vegetation, with *Palustriella falcata, Philonotis calcarea, Carex dioica, Gentiana verna* and *Selaginella selaginoides*, and the montane to alpine zonal nature of the flora was evidenced by *Lophozia obtusa, Gentiana acaulis, G. pyrenaica, Pedicularis kerneri, Phleum alpinum, Plantago alpina* and *Primula integrifolia*.

Five bulk samples were taken, each consisting of 1-3 litres of cut vegetation and litter from within separate areas of 50 x 50 cm. The samples were taken from spots selected to represent minor variations in the vegetation across the site. These samples were air-dried, sieved and all Mollusca were separated and counted. Results from the five samples are pooled because no clear differences were found between samples. Nomenclature of Mollusca mainly follows Kerney (1999[6]), but Bernasconi (2000[10]) for *Bythinella* and Waldén (1986[11]) for *Vertigo* spp.

The molluscan fauna like the flora illustrates the richness of the site, with 14 species recorded and high counts of shells of some species. Taxa and numbers of shells recorded

were, *Bythinella baudoni* (Paladilhe) (38), *Lymnaea truncatula* (Müller) (42), *Cochlicopa lubrica* (Müller) (1), *Vertigo antivertigo* (Draparnaud) (12), *Vertigo substriata* (Jefferys) (149), *Vertigo modesta arctica* (7), *Punctum pygmaeum* (Draparnaud) (5), *Vitrina* sp. (1), *Nesovitrea hammonis* (Ström) (34), *Euconulus alderi* (Gray) (41), *Trichia* sp. (1), *Pisidium casertanum* (Poli) (25), *Pisidium personatum* Malm (16), and *Pisidium* sp. (3 immatures). *V. modesta arctica* was undoubtedly present only at low density in the fen. Field searches showed that it was apparently absent from drier slopes nearby, e.g. under *Juniperus* bushes.

The name *Vertigo modesta arctica* used throughout this paper follows Waldén (1986[11]) but with some reservations because there is uncertainty regarding the taxonomy of *V. modesta* (Say, 1824) and its allies and the precise identity of the specimens from Andorra. *V. arctica* (Wallenberg, 1858) is treated at species rank by Pokryszko (1990[12] pp. 198-200, 2003[13]) but as the subspecies *V. modesta arctica* by Waldén (1986[11]) and von Proschwitz (2003[7]) and simply as *V. modesta* by Turner *et al.* (1998[4]) and Kerney (1999[6]).

The specimens from Andorra were compared by me with material of *V. modesta modesta* from Alaska, *V. modesta arctica* from northern Sweden and *V. extima* (Westerlund, 1877) from Alaska, including shells of these taxa determined by H. Waldén. The mature Andorran shells measure 2.3 x 1.35-1.4 mm. They are thus mainly smaller and somewhat broader in proportion to shell height than Scandinavian *V. modesta arctica* (see Waldén 1986[11] p. 46), but within the size range of specimens from the Col del Pam given by van Regteren Altena (1935[1]) and those given by Pokryszko (1990[12] p. 196). The Andorran shells also differed from the *V. modesta arctica* seen in their slightly deeper suture, darker colour (always mid-brown rather than light yellow-brown), mainly stronger irregular growth ridges, and weak teeth (of the four adult *V. modesta arctica* shells, three had no teeth present, the fourth had low teeth which were visible only under magnification: one columellar, one parietal). Waldén (1986[11] p. 46) described *V. modesta arctica* as possessing 1-4 teeth. However, van Regteren Altena (1935[1]) noted that all but one of the twelve Pyrenean specimens from the Col del Pam lacked teeth (one had a single rudimentary parietal tooth). Mermod (1930[14]) notes that in the Alps it can be variable with 0-3 teeth. Kerney & Cameron (1979[15] p. 73) note 'usually with 3-4 rather deeply-set small denticles'; Pokryszko (1990[12] p. 197) notes 0-4 teeth. Study of more material will be necessary to ascertain whether Pyrenean populations differ consistently from those of the Alps, Scotland and Scandinavia.

The habitat in Andorra differs markedly from that in Scotland where it is found on ledges with low *Salix* bushes (Marriott & Marriott 1988[5]), and from the habitat described by Bech (1990[2]) in north-east Spain, loosely translated as 'humid shady places, bushy, under stones or resting on the soil'. Kerney & Cameron (1979[15]) give a similar description of damp shaded places, characteristically in subarctic woodland on valley slopes, under stones and ground litter. van Regteren Altena (1934[1]) describes the habitat at Col del Pam as beneath debris of branches fallen into the bed of a small dry stream, completely covered by *Saxifraga* sp.; its only molluscan associate there was *Balea perversa* (L.). Mermod (1930[14]) describes the habitat in Switzerland, as being in high valleys in very humid sites associated with marshes. von Proschwitz (2003[7]) gives a broad range of habitats, mainly sub-alpine birch forests, or above tree-line in humid valleys with luxuriant herb-vegetation and *Salix* scrub, or in rich and medium-rich fens. Turner *et al.* (1998[4]) describe a microhabitat among overgrown debris on stream banks and marshy/boggy places over montane limestone and basic metamorphic rocks. The site in Andorra thus appears most similar to those described from Switzerland by Mermod and from some of the Scandinavian sites described by von Proschwitz.

Finally, the *Vertigo substriata* found at this locality is only the second record of this species from Andorra where it was first reported by Bertrand (1997[16]).

I would like to thank Dr David T. Holyoak for help with the identification of the

vascular plants and for the identification of bryophytes. Dr Roy Anderson and Dr Barry Colville are thanked for loans of specimens of *V. modesta* and *V. extima*, and Gerhard Falkner for help with French literature. I am also indebted to an anonymous referee for helpful comments on a draft of this paper.

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Geraldine A. Holyoak
8 Edward Street
Tuckingmill, Camborne
Cornwall TR14 8PA
EMail: ger@gholyoak.fsnet.co.uk

AEGOPINELLA NITIDULA (DRAPARNAUD) AS PREDATOR ON *BALEA BIPLICATA* (MONTAGU)

Balea biplicata (Montagu) is one of the rarest clausiliid species in Sweden, known from only 32 scattered localities in the southernmost part of the country. In the latest version of the national red-list, it is placed in category NT. In 1993 an attempt to preserve one of the populations by re-localisation was made, as the locality (situated in the city area of Göteborg) was threatened by exploitation (von Proschwitz, 1994[1]). Totally 3078 living specimens were transplanted into a similar, protected habitat in the brook valley "Vitsippsdalen" within the area of the Botanical Garden, Göteborg. The size of the population and its demography is checked every year with capture-recapture techniques.

Already at the control in 1994 it was observed, that three of the dead shells found had holes in one or two of the lower whorls, approximately in the region where the shell reaches its largest width. The edges of the holes were such that the injuries seemed to be the result of an attack by some other snail species. When the population was checked in 1995, no less than 13 empty shells with holes of the same type were found. On the same occasion I also detected a living adult specimen of *B. biplicata* onto which an adult specimen of *Aegopinella nitidula* (Draparnaud) had attached itself with its foot wide spread over the thickest part of the clausiliid shell. I continued to observe the two snails, and for almost two hours the *Aegopinella* remained still in this position. The *Balea* was surprisingly passive during this phase only making lame, unsuccessful attempts to get rid of the intruder. After 1 hour and 52 minutes the *Aegopinella* moved and revealed an irregular but almost 2,5 mm wide hole in the shell. Into this hole it entered its head and forepart and started to eat on its helpless victim. After 45 minutes it had completely consumed the soft parts of the *Balea* and withdrawed from the empty shell.

During the first phase the *Aegopinella* obviously extracted calcium from the *Balea*-shell. This behaviour, of dissolving and absorbing calcium ions from materials rich in this element is common among land snails (Kühnelt, 1932[2]) and consists of two parts: 1) Active dissolving through corrosion by lowering of the pH (release of acid) and 2) Absorption of calcium ions through the sole epithelium (Bensalem & Chétail, 1982[3]). Corrosive etching by *A. nitidula* on shells of *Helix pomatia* L. is described, and the typical damages illustrated by Falkner (1990[4]). The second phase of the attack started when the shell was etched through. It seems probable that after what started as extraction of calcium, the carnivorous instincts of the *Aegopinella* takes over, as the soft parts of the *Balea* are exposed and it is consumed as a prey. Several species of the family Oxychilidae, among them members of the closely related genus *Oxychilus* are known to be facultative carnivores, consuming other land snail species (cf Schmidt 1960[5]). Empty shells with the characteristic marks of predation by *Aegopinella* are found every year in the re-localised population. This has, however, not prevented *B. biplicata* from establishing itself in the new site at a population size of approximately 1500 specimens.

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AFROPUNCTUM SEMINIUM (MORELET) AS A GREEN HOUSE SPECIES IN SWEDEN

In February 1999 the hothouses of the Botanical Garden in Göteborg (SW Sweden) were searched for land and freshwater molluscs. The purpose was to investigate the status of the introduced mollusc fauna. The hothouses have been sampled for snails at several occasions since the 1920's and it was here the first Swedish record of *Hawaiia minuscula* (Binney) was made in 1982 (von Proschwitz 1983[1]). In 1980, however, the many of the old glass houses were turned down and replaced with modern ones. The search in 1999 was the first close sampling in the new houses.

The search showed, that some well-known anthropochorous green house species were rather well spread: *H. minuscula*, *Oxychilus draparnaudi* (Beck), *Zonitoides arboreus* (Say), *Lehmannia marginata* (O.F. Müller) and *Deroceras leave* (O.F. Müller) [aphallic '*sandwichiense*'-form]. Also some native species [e.g. *Discus rotundatus* (O.F. Müller), *Oxychilus alliarius* (Miller)] were rather spread and common in all the hothouse sections.

In one of the orchid houses, however, large numbers of a small, conical, euconulid-like snail were observed. The snails were creeping on the sides of clay-pots with orchids and also on the wet surface of the earth in the pots. No damage to the plants could be observed, and this was confirmed by the staff working in the orchid houses. The staff had observed the snails for several months without recognising any damage to the plants. Probably the snails are feeding on algae, growing in and on the clay-pots. In ten minutes of searching 57 specimens of different ages were found. At later visits to the orchid house, several hundred specimens could be observed. An investigation with a magnifying-glass revealed that the species was ovo-viviparous - most of the adult specimens were pregnant with 1-3 embryos of different size. More information on the occurrence is presented by von Proschwitz (2001[2]).

After some research in the literature the specimens were strongly presumed to belong to *Afropunctum seminium* (Morelet) a presumption that could be verified after comparison with material in the collection of MNHN in Paris. A dissection of some animals and a comparison of the genital apparatus with the figures in de Winter & van Bruggen (1992[3]) gave further evidence that the determination was correct.

A. siminium is native in Africa, occurring in the tropical belt from Senegal in the west to Kenya and northern South Africa in the east – cf. distribution maps in de Winter & van Bruggen (1992[3]) and Verdcourt (1981[4]). The systematic position of *A. siminium* was long unclear and it has been placed variously in the Endodotidae, Punctidae, Charopidae and Euconulidae (cf. Verdcourt 1981[4], 1972[5], van Bruggen & Meredith 1984[6]). The final evidence for its position in the Euconulidae was given by de Winter & van Bruggen (1992[3]).

A large number of *A. siminium* was found by A. J. de Winter in the orchid compartment of the tropical greenhouses of the Department of plant taxonomy of the Agricultural University, Wageningen, The Netherlands in 1986, under conditions which seem very similar to those in the orchid house of the Botanical Garden of Göteborg, Sweden. In the former case, the snails occurred in a department with orchids from Gabon – which strongly indicated the African origin. In Göteborg the orchids were imported from several Botanical Gardens in Europe, so no definite origin could be stated. A spread with plants, exchanged between Botanical gardens, as predicted by Verdcourt (1987[7]) is evidently in progress. Possibly the species is already established elsewhere. Further passive dispersal by the help of man is to be expected. The small size of *A. siminium* enables it to be transported readily with plants. The ovo-vivipary facilitates its establishment in the 'disturbed' habitat which the tropical hothouses exhibit.

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VERTIGO EXTIMA (WESTERLUND) IN CARELIA

During a recent revision of parts of the collections of the genus *Vertigo* in the Staatliches Museum für Tierkunde, Dresden, Germany, I came across an undetermined sample from the Kiwatsch nature reserve in the southern part of Carelia, W. Russia. The sample (coll. Nr. 34233, leg: F. Höhler & S. Heimer, end of September 1989) consisted of two adult specimens of which one was *Vertigo alpestris* (Alder), the other could be identified as *Vertigo extima* (Westerlund).

V. extima is one of the poorest known European species of the genus *Vertigo*. Although described by Westerlund as early as (1877[1]), its status as species has only been recognised for about 15 years (Waldén, 1986[2]). The species has a pronounced subarctic-Siberian distribution, the details of which are, however, known only roughly. Most of the localities are situated in the northernmost parts of Fennoscandia. Furthermore, *V. extima* has been found in three localities in easternmost Siberia and one in Alaska. Between the Fennoscandian and the E. Siberian distribution areas, there is an isolated occurrence at Baklanowskij in the Jenisej region (cf distribution map in Waldén 1986[2]).

Geographically the record from the Kiwatsch nature reserve is probably to be seen as an extension of the Fennoscandian distribution area, although it is situated approx. 1000 kms SE of the easternmost of these localities (Bojobaeske in the province of Finnmark, Norway). Situated at 62′25°N; 33°E, Kiwatsch is the southernmost of the known localities for the species, and just as the records at Baklanowskij (64′25°N) in Central Siberia and at Trångsviken (63′35°N) in the province of Jämtland, Sweden (its southernmost occurrence on the Scandinavian peninsula) it is situated, not in the sub-arctic Tundra-zone, but in the boreal Taiga-region.

The occurrence of *V. extima* in Kiwatsch, together with the two southerly records mentioned above, indicates that it may not be so strongly bound to the Tundra-zone as earlier presumed, but that the species may occur far more to the south, in the Taiga-region. The ecological information concerning the habitats of these isolated occurrences is, however, incomplete. The locality in Jämtland, Sweden is a calcareous marsh forest. Nothing is known of the habitats at Baklanowskij or in Carelia. The sample from Kiwatsch, also contained the following species: *Discus ruderatus* (Férussac), *Euconulus fulvus* (O.F. Müller), *Limax cinereoniger* (Wolf), *Deroceras leave* (O.F. Müller), *Arion fuscus* (O.F. Müller), *Arion circumscriptus* Johnston. This species composition indicates that the sample, labelled ´Kiwatsch Reservat´ consists of lumped material from several localities and habitats within the area.

The total distribution of *V. extima* is still very incompletely known, and further collecting is needed to show if the large distribution gaps in Siberia are real, and the species thus has a disjunct N. Asian - NW. European distribution. It may, however, also be possible that *V. extima* has a circumpolar distribution, just as the closely related form-group of *Vertigo modesta* (Say) and the Taiga species *Zoogenetes harpa* (Say).

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Ted von Proschwitz
Natural History Museum
Box 7283
S-40235 Göteborg
Sweden

OBITUARY: THOMAS PAIN (1915–2003)

Tom Pain who died aged 87 on 2nd June 2003 had a remarkably wide knowledge of both marine and non-marine molluscs, both recent and fossil. He will be remembered mostly for his extensive work on tropical African non-marine molluscs (much of it together with T.E. Crowley). He was particularly interested in ampullariids and achatinids. His favourite marines were the whelks. He quite definitely was not keen on tiny species.

He was born at Brentwood, Essex on the 13th October 1915 during a zeppelin raid on London. His father Tom married a wealthy lady Clara Freeman and there were three children. The eldest, Henry, was 17 years older than Tom and after Sandhurst had obtained a commission in the army; the youngest, Catherine, became a nurse. He went to Brentwood public school where he enjoyed rugby and cross country running. His interest in natural history developed early. During summer holidays he went with his nanny and sister to Walton on the Naze and discovered butterflies, moths and fossils. The area is an ideal one with diverse habitats of grassland, scrubby woodland and salt marsh apart from the London Clay and Red Crag deposits. Whilst still at school in the early 1930's he worked as an assistant to the curator of the Chelmsford and Essex Museum – at first voluntarily but later as a paid worker. One of his first jobs concerned sorting out a box of shells from the Ritson collection which was the start of his interest; this collection contained some *Ampullaria* which were to become his specialisation. Whilst working on this collection he visited the Natural History Museum and met Major G.I. Crawford then head of the mollusc section. He was introduced to Hugh Fulton, the surviving partner of the shell dealers Sowerby & Fulton. He also met E.G. Alderson the author of the revision of *Ampullaria* who died in 1933. This gave great impetus to Tom's growing interest in Mollusca. He began to study for a geology degree at Imperial College but in 1938 gave this up to become curator of the Georgetown Museum in what was then British Guiana. He stayed there three years, during which time he had the great good fortune to join an expedition to Mt. Roraima, the great flat plateau at the junction of Brazil, Venezuela and Guyana which had inspired Conan Doyle's 'Lost World'. There were no dinosaurs of course and virtually no mammals or snails but they collected butterflies and other insects. Much of it is in the Hope Department of Entomology at Oxford University Museum. The swamps around Georgetown were ideal habitats for ampullarids and his interest in the family grew. The climate in Georgetown is appalling and he opted not to do another tour of duty there but went to Jamaica where he invested in and helped run a hotel business. He also collected and sold snails and marine shells to the well known dealer Walter Freeman Webb. He was lucky to be able to visit the famous cockpit area with its innumerable operculate snails. From Jamaica he visited Cuba, the Cayman Islands and Nicaragua. He collected land snails for Paul Bartsch of the U.S. National Museum. A collection of Jamaican marine shells is in the Chelmsford Museum.

The hotel business ceased to be viable and in 1941 Tom decided to return to England but the Fyffes' banana boat he travelled in was torpedoed. A Royal Mail ship bound for Buenos Aires very fortunately sighted the lifeboat he was in and he arrived in Buenos Aires just before Christmas 1941. Christmas was spent luxuriously with the British Ambassador at the Embassy. Tom made light of this enemy action but he was lucky to have survived. He finally reached Liverpool in the Blue Star liner Andalusia Star and fortunately without incident save that the ship which was of course in convoy was so much faster that it was eventually given permission to go it alone.

He was of course called up and joined the Royal Corps of Signals but later transferred to the Royal Army Education Corps for the rest of the war stationed at Dover. After being demobbed he worked for British Rail for 35 years based on St. Pancras, first as a guard but eventually as a Senior Conductor. This had great practical benefits since he could travel for almost nothing for the rest of his life. The rest of us who had to pay a King's ransom for a short journey were always envious!

Just after the war his interest in molluscs intensified and he joined the Malacological Society in January 1946 and the Conchological Society at the end of the same year. He had been very unfortunate with his collections from America. Those he had with him went down with the boat and those in Georgetown Museum were destroyed when that was burnt down in the 1944 fire. Only material he had posted home survived including specimens later to become types of several new species. His collection and library grew very quickly and occupied more room than anything else. When Fulton died his wife was left with the shell business including a huge collection. Despite help from A. Blok and G. Wilkins it proved impossible to make the business pay during the war. Tom had been left some money and bought the land and freshwater part. He became friendly with Major Connolly the expert on African non-marine Mollusca who was an honorary worker at the Natural History Museum and helped him as an honorary curator. Connolly died in 1947 and although he had officially given much of his huge collection to the Museum years before quite a lot of material and books passed to Tom. Tom often told the story of having been introduced by Malcolm to his son Cyril Connolly with the words this is my son – he is a fool! A rather harsh judgement on an old Etonian who, even before his father's death, was a literary giant.

I was always amazed at the number of times Tom changed his address in the early days until he ended up in Landseer Buildings then Reynolds House in Millbank just behind the Tate Gallery. I remember him telling me that the rent was much less than he would have had to pay to keep his books and collections in a warehouse! He could produce almost any book you needed and specimens of almost any genus. Eventually some of it had to go and he pruned his collections and sent a great deal to the Melvill-Tomlin collection at Cardiff. His land and freshwater material and whelks will go to this institution. A card index which Tom kept shows that he had holotypes or paratypes of 232 taxa. The collection included material from classical collections such as G.B. Sowerby III and E.G. Alderson.*

There was undoubtedly friction between Tom and the Mollusca Department of the Natural History Museum which resulted in him not being allowed to work there. He had early annoyed Major G.I. Crawford by very foolishly putting a degree after his name to which he was not entitled. Crawford was a stickler and went out of his way to investigate. Apart from this he undoubtedly borrowed material without proper permission. I became innocently involved in this because he gave me some material to photograph and when the photographs were published (PAIN 1949c) they were acknowledged to the British Museum photographer! I said nothing to anybody not even to Tom. I suspect it was Bill Rees who found out. He had been in charge of molluscs since just after the war. He did not like Connolly or Tom nor me – all amateurs. In fact he warned me to beware of Connolly's determinations! None of this mattered since Tom collaborated with Crowley who had always had good relations with the department.

Tom left the Malacological Society about ten years after joining. The Conchological Society was very much to his taste and he was a very regular attender at meetings until the end of his life and very frequently put on interesting exhibits. He joined the council in 1967 and became President in 1970–71; his Presidential Address was of course on the Ampullariidae [PAIN 1972b]. Above all he will be remembered as the officer who for years arranged field meetings; he had a particular flair for this – possibly the discipline of work on the railways had something to do with it. He also arranged geology and land snail field meetings for other societies particularly the Northampton Natural History Society of which he became President.

* It would be out of place to attempt to list all these but it is hoped Cardiff will prepare a catalogue in due course.

Tom was admitted a Fellow of the Linnean Society in 1972 and there is no doubt he enjoyed attending meetings of scientific societies. He was an enthusiastic member of the British Shell Collectors' Club of which he was president in 1977–1979 and 1994–1997. He had in later life become interested in British marine mollusca and worldwide Buccinidae and Muricidae. He also had a large collection of Jurassic ammonites which were eventually sold.

Apart from molluscs he was interested in Egyptology and archaeology in general. He helped Sir Mortimer Wheeler and Margaret Murray with shell identifications. Trees, especially conifers, interested him and the larger fungi.

Tom married Doreen Gantzer before the war and they had one son Christopher. Later he met Marjorie Whittaker who changed her name by deed poll to Pain and they had a daughter Susan. Tom and Marjorie separated in 1957 and she settled in Kenya where she worked at St Andrews School at Turi. She retained her interest in snails and some of her collections are in the National Museum of Kenya including some new taxa. Marjorie Powell was killed in a motor accident a few years later. Tom later married Celia Janet Honnor who had joined our Society in 1966.

Undoubtedly Tom and Celia did a great deal to encourage people to support our Society by their enthusiasm for molluscs and great support of its meetings and helped keep the Society in the best traditions of those catering for amateur natural historians.

I am very grateful to Celia Pain for many of the details about Tom's life which despite knowing him over 55 years I knew nothing about.

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PAIN T. 1985a The genus *Japelion* Dall, 1916 (*Prosobranchia: Buccinidae*) *La Conchiglia* **17** (194–195): 24–27, figs.

PAIN T. 1985b The buckie *Pallidula* No 1 (61) (sic): 6–7.

PAIN T. 1986 Linnaeus' *Neptunea,(Mollusca: Gastropoda) Zoological Journal of the Linnean Society* **88**: 291–306, 6 figs (with C.M. Nelson).

PAIN T. 1987a The genus *Clinopegma* Grant & Gala, 1931 *La Conchiglia* **19** (222–223): 3, figs.

PAIN T. 1987b Corrections to the first printing of Abbott & Dance, 'Compendium of Seashells' 1982 Family Bursidae. *Pallidula* **18 (3)**: 37.

PAIN T. 1987c The saga of the turban star shell *Megastraea turbanica* (Dall) *Pallidula* **18 (2)**: 19–21.

PAIN T. 1988 A new look at *Echinophoria* Sacco, 1890 *La Conchiglia* **20** (236–237): 19 figs.

PAIN T. 1989a *Rangia cuneata*, the clam they built a town on *Pallidula* **19 (4)**: 62–63.

PAIN T. 1989b *Cassis nana* and *thompsoni*: range extensions *Pallidula* **19 (4)**: 73.

PAIN T. 1990a *Cassis bituberculosa* v. Mts. 1901 a species of *Echinophoria* Sacco, 1890 *La Conchiglia* **22** (250–252): 6–7, fig. (with G.H.J. Cox).

PAIN T. 1990b *Ceratostoma coreanicum* (A. Adams, 1854) a synonym of *C. burnetti* Adams & Reeve, 1849) *La Conchiglia* **22** (256): 22, figs.

PAIN T. 1990c The saga of the 'blubber-lipped bulimus' *Pallidula* **20 (2)**: 21.

PAIN T. 1991 *Pleurotomaria*: 225 million years of perseverance? *Pallidula* **21 (2)**: 7–10.

PAIN T. 1992a The genus *Megastraea* McLean, 1970 (*Archaegastropoda: Turbinidae*) La *Conchiglia* **23** (263): 4, 4 figs.

PAIN T. 1992b Gordon Osborn F.L.S., 1913–1991 *Pallidula* **22 (1)**: 5.

PAIN T. 1992c A brief look at ammonites *Pallidula* **22 (1)**: 16–19.

PAIN T. 1993 Review of I. Bogdanov and B. Sirenko 'Seashells of Russia in colour' *Pallidula* **23 (2)**: 26–27.

PAIN T. 1994 The giant creeper *Campanile symbolicum* Iredale a relict from Australian waters *Pallidula* **24 (1)**: 18–20.

PAIN T. 1995a A living fossil from the southwest Pacific *Gourmya gourmyi* (Crosse) *Pallidula* **25 (1)**: 18–20.

PAIN T. 1996b *Neotrigonia*, a sole survivor! *Pallidula* **26 (1)**: 22–23.

PAIN T. 1996c The repetitive shell name once again *Pallidula* **26 (1)**: 25.

PAIN T.1997 The killer sea snail *Conus geographus* Linnaeus, 1758 *Pallidula* **27 (1)**: 17–18.

PAIN T. 1998 Our common whelk *Buccinum undatum* Linné, 1758 *Pallidula* **28 (1)**: 6–7.

PAIN T. 2000 Terence Eldon Crowley 1915–1999: obituary, bibliography and new molluscan names *Journal of Conchology* **37**: 93–97 (with C. Pain).

NEW TAXA

(Figure numbers in bold refer to the photographs in this issue)

Achatina bandeirana arenaria Crowley & Pain 1961h: 139, fig. 1. Holotype: Congo Republic (Brazzaville), Pointe Noire, *Dartevelle*, MRAC 185116 **(fig. 19)** (one paratype MRAC 185104; one paratype NMW.Z.1981.118.00098).

Achatina bandeirana mayumbensis Crowley & Pain 1961h: 141, fig. 2. Holotype: Zaire, Mayumbe, Mt. Madiakoko, Kisala Ngoma, *Dartevelle*, MRAC 283366 **(fig. 17)** (one paratype MRAC 531968; one paratype NMW.Z.1981.118.00099).

Achatina (Lissachatina) calcicola Crowley & Pain 1961h: 144, fig. 4. Holotype: Zaire, Bas-Congo, Inkisi, Sanda, *Bequaert*, MRAC 142968.

Achatina (Pintoa) lomaniensis Crowley & Pain 1961h: 147, fig. 5. Holotype: Zaire, Lomami, Kasai, *Lutz*, MRAC 97115 (two paratypes MRAC 277907; one paratype NMW.Z.1981.118.00161).

Achatina (Lissachatina) mulanjensis Crowley & Pain 1981b: 954, t. 6/1–4. Holotype: Malawi, Mulanje Mt., *W.N. Gray*, MRAC 800985 **(fig. 21)** (one paratype MRAC 800986; one paratype NMW.Z.1981.118.00105; one paratype NMW.Z.1981.118.00235).

Achatina schweinfurthi simularis Crowley & Pain 1961h: 142, fig. 3. Holotype: Zaire, Buta, Province Orientale, Uele District, *Hutsebaut*, MRAC 302304 (one paratype MRAC 302299)

Archachatina (Tholachatina) altitudinaria Crowley & Pain 1961h: 151, fig. 8. Holotype: Zaire, Kivu, Fizi, 2800 m, *Hautmann*, MRAC 277868 **(fig. 13)** (one paratype MRAC 277869; one paratype MRAC 277881; one paratype MRAC 277893; two paratypes NMW.Z.1981.118.00163; one paratype MCZ 235245).

Archachatina (Tholachatina) bequaerti Crowley & Pain 1961h: 148, fig. 6. Holotype: Malawi, Nyika Plateau, 2250 m, *Loveridge*, MCZ 235271 **(fig. 14)** (two paratypes MCZ

232272; one paratype NMW.Z.1981.118.00162).

Archachatina (Tholachatina) insularis Crowley & Pain 1961h: 149, fig. 7. Holotype: Zaire, Bas-Congo, Matadi, island in mouth of R. Congo, *Dartevelle*, MRAC 114917 (two paratypes NMW.Z.1981.118.00104; three paratypes NMW.Z.1981.118.00236; one paratype MCZ 235278; one paratype MCZ 235247, one paratype MMUM).

Burtoa nilotica benoiti Crowley & Pain 1959d: 22, t. 2, fig. 8. Holotype: Zaire, Rutshuru, *J. Ghesquière*, MRAC 101001**(fig. 12)** (three paratypes MRAC 101002; four paratypes MRAC 101005; four paratypes MRAC 101009; one paratype NMW.Z.1981.118.00170; one paratype LEEDM.C.1993.5.15366).

Burtoa nilotica congoensis Crowley & Pain 1959d: 26, t. 2. fig. 9. Holotype: Zaire, Haut Lomani, between Sampwe and Kikondja, *Tonneau*, MRAC 5072 **(fig. 16)** (one paratype NMW.Z.1981.118.00169; one paratype (?) LEEDM.C.1993.5.15356 [Crowley designated this as a paratype but it is not from the type locality]).

Burtoa nilotica verdcourti Crowley & Pain 1959d: 12, t. 1, figs 1–2. Holotype: Kenya, Kavirondo, Rusinga site 3, *L.S.B. Leakey* 572/56, BMNH (Four paratypes, BMNH).

Chicoreus (Chicoreus) kilburni Houart & Pain 1982d: 51, figs. Holotype: S. Africa, Natal, Durban Bay? *Kilburn*, IRSN 26429/385.

Doryssa geijskesi Pain 1956d: 102, figs 10a–d. Holotype: Surinam, Coppename R., Makambo, *Geijskes*, RMNH (paratypes in Coll. Geijskes and Pain - specimens can currently not be located).

Grandidieria bloomeri Woodward in Crowley, Pain & Woodward 1964g: t. 7, figs. 41, 42. Holotype: Malawi, Lake Malawi (Nyasa), Nkata Bay, Eccles Point, *Eccles*, MRAC 793223 (two paratypes MRAC 793222)

Lanistes (Meladomus) connollyi Pain 1954a: 2, figs. 1, 2. Holotype: Zimbabwe, Victoria Falls, *Connolly*, MCZ 173421 (three paratypes NMW.Z.1981.118.00112; two paratypes NMW.Z.1981.118.00233; one paratype MRAC 793978; one cited specimen NMW.Z.1981.118.00111).

Lanistes kobelti Pain 1954a: 31: 1, figs. 3, 4. Holotype: probably West Africa, MCZ 173419 (one paratype NMW.Z.1981.118.00115).

Lanistes (Meladomus) ovum mweruensis Pain 1954a: 3, fig. 5–7. Holotype: Zaire, Lake Moero (Mweru), Kilwa, *Van den Berghe*, MCZ 109842 (six paratypes NMW.Z.1981.118.00219; one paratype NMW.Z.1981.118.00234; two paratypes MRAC 554469).

Limicolaria leakeyi Crowley & Pain 1963c: 15, figs. 24–26. Holotype: Kenya, Songhor, Miocene, *L. Leakey and colleagues* 648/49, BMNH (one paratype NMW.Z.1981.118.00238; one paratype LEEDM.C.1993.5.18488). (Pickford has demonstrated this is an *Achatina*).

Limicolariopsis cylindrica Crowley & Pain 1961g: 16, t. 1, figs. 6, 7. Holotype: Kenya, Northern Frontier District, Malka Murri, *J.G. Williams*, MRAC 793488 **(fig. 5)** (one paratype NMW.Z.1981.118.00153 (the material was originally loaned from NMK and Pain (2000) states the type is there although it must already have been sent to MRAC in error) (as '*cylindricus*').

Limicolariopsis elgonensis Crowley & Pain 1961g: 29, t. 3, fig. 3. Holotype: Kenya, E. Mt. Elgon, Endebess, *Irwin*, NMK (two paratypes NMW.Z.1981.118.00152; one paratype MRAC 617707; one paratype MRAC 617712; one paratype MRAC 617718; one paratype MRAC 617728; one paratype MRAC 617733).

Limicolariopsis ellisi Crowley & Pain 1964e: 191, figs. 5, 6. Holotype: Ethiopia, Gore, Kaffa, *Chojnacki*, MRAC 608889 **(fig. 20)** (on p. 192 fig. 6 is wrongly referred to *L. obtusa*).

Limicolariopsis laevis Crowley & Pain 1961g: 28, t. 3, figs. 1, 2. Holotype: Kenya, Mt. Kenya, Thiba R., *H. Copley*, NMK No. 955 (one paratype NMW.Z.1981.118.00154).

Limicolariopsis verdcourti Crowley & Pain 1961g: 26, t. 2. fig. 9, text fig. Holotype: Kenya, W. Mt. Kenya, Naromoru R., 2910 m, *M. Coe*, NMK.

Neothauma ecclesi Crowley, Pain & Woodward, 1964g: 19, t. 2, figs. 8–10. Holotype: Malawi, Lake Malawi (Nyasa), Chipoka, *Eccles*, MRAC 793221 **(fig. 1)** (Mandahl-Barth transferred this to *Bellamya*).

Nyassunio ecclesi Woodward in Crowley, Pain & Woodward 1964g: 52, t. 6, figs. 39, 40. Holotype: Malawi, Lake Malawi (Nyasa), Chembe, *Eccles*, MRAC 793224 **(fig. 8)** (three [non-matching valves] paratypes NMW.Z.1981.118.00101).

Pila (Pomacea) aldersoni Pain 1946a: 180, t. 6, figs. 1, 2. Holotype: Ecuador, about 272 km SE. of Quito, near Santa Barbara, *Pain*, BMNH 1946.6.24.25 (one paratype NMW.Z.1981.118.00091; one paratype NMW.1955.158.02411).

Pila ovata dartevellei Pain 1961f: 17, fig. Holotype: Zaire, Lumbumbashi (Elizabethville), *Ercoliers*, MRAC 36662 **(fig. 5)** (paratype cited as being in coll. Pain).

Pila (Pomacea) hollingsworthi Pain 1946a: 180, t. 6, figs. 3–5. Holotype: Colombia, near Bogota, *Pain*, BMNH 1946.6.24.24 (one paratype NMW.Z.1981.118.00232).

Placostylus fibratus kumacensis Pain 1958a: 276, t. 8. Holotype: New Caledonia, above Kumac on NW. coast, Tiebagi Mts., *Humble*, NMW.Z.1981.118.00220 **(fig. 4)**.-

Placostylus fibratus mosesi Pain 1955: 14, fig. 4. Holotype: New Caledonia, near Goro, *C.H. Humble*, NMW.Z.1981.118.00221 **(fig. 10)**.-

Placostylus fibratus powelli Pain 1955: 12, fig. 2. Holotype: New Caledonia, Baie du Sud, *C.H. Humble*, NMW.Z.1981.118.00224 **(fig. 7)** (one paratype NMW.Z.1981.118.00222).

Placostylus scarabus verdis Pain 1955: 14, fig. 5. Holotype: New Caledonia, N. coast near St. Vincent, *C.H. Humble*, NMW.Z.1981.118.00223 **(fig. 6)**.-

Placostylus strattoni Pain 1955: 18, fig. 9. Holotype: New Caledonia, without definite locality or collector, in coll. *Stratton*, MMUM (see *Journal of Conchology* 27: 428 (1972) **(fig. 9)**.-

Pleiodon waterstoni Pain & Woodward 1964f: 9, t. 2, figs. 1–3. Holotype: locality (? Senegal) and collector unknown. Specimen in A.E. Salisbury collection NMSZ 1961.61.32801 **(fig. 11)** (one paratype NMSZ 1961.61.32802).

Pomacea camena Pain 1949c 258, t. 13, figs. 5, 6. Holotype: Venezuela, near Lagunella, 800 m, *Pain*, BMNH 1946 10.2.3 (given as 10.2.4 paratype in BMNH accession book) (two paratypes NMW.Z. 1981.118.00116; one paratype NMW.1955.158.02412).

Pomacea cumingi urabaensis Pain 1956a: 75, text fig. Holotype: Colombia, N. Antioquia, Golfo de Uraba, *Brouwer*,in original publication cited as T. Pain collection (three paratypes NMW.Z.1981.118.00114).

Pomacea falconensis Pain & Arias 1958c: 6 t. i, ii. Holotype: Venezuela, Falcón State, 5 km. SW. of Chichiriviche, *A. Musso & G. Yépez*, Mus. Hist. Nat. La Salle Cat. Mol. No 4000; (paratypes BMNH 19592; four paratypes NMW.Z.1981.118.00116; three paratypes NMW.Z.1981.118.00230).

Pomacea (Limnopomus) meridaensis Pain 1950b: 109. Holotype: Venezuela, Merida, collector's name not given, formerly in Alderson coll. in Lady Iliffe collection (figure by Alderson 1925, t. 11, fig. 7) now at NMW.Z.1981.118.00109 **(fig. 2)** (three paratypes NMW.Z.1981.118.00110, one paratype MMUM EE.3638).

Pomacea nais Pain 1949c: 257, t. 13, figs 3, 4. Holotype: Brazil, near Obidos, small stream from South bank of R. Amazon, *Pain*, BMNH 1946.2.3.1 (one paratype NMW.Z.1981.118.00093).

Pomacea vickeryi Pain 1949c: 257, t. 13, figs. 1, 2. Holotype: Argentina, La Plata, near Buenos Aires, *Pain*, BMNH 1946.10.2.3

Pomacea zischkai Blume & Pain 1952b: 267, t. 7. Holotype: Bolivia, Chapara region, 400 m, *Zischka*, Blume collection (two paratypes NMW.Z.1981.118.00117).

Pseudachatina connectens d'Ailly forma **colorata** Pain & Paul 1967d: 35, t. 2, fig. 3. Holotype: possibly S. Cameroons, near Tiko, Likomba Platantation, in bananas, collector? In original publication cited as T. Pain collection (one paratype NMW.Z.1981.118.00226; one paratype MRAC 793674).

Pseudachatina connectens d'Ailly forma **plicata** Pain & Paul 1967d: 37, t. 2, fig. 6. Holotype: S. Cameroons, Dibonga Sanaga Rinie, (ex Preston) NMW.Z.1981.118.00225 **(fig. 15)**.

Pseudachatina granulata Pain & Paul 1967d: 41, t. 2, fig. 5. Holotype: S. Cameroons, 11 km inland from Kribi, collector not known, BMNH 1937.12.30.3674 (ex Preston and Connolly).

Pseudachatina pulchra Pain & Paul 1967d: 42, t. 3, fig 1. Holotype: possibly W. Cameroons, near Tiko, Likomba Plantation, in bananas, in original publication cited as T. Pain collection (one paratype LEEDM.C.1993.5.18472).

Pseudachatina sodeni Kobelt forma **elegantula** Pain & Paul 1967: 30, t. 1, fig. 2. Holotype: Fernando Po, Santa Isabella, ?collector, BMNH 1904. 5.7.26 (two paratypes NMW.Z.1981.118.00151; two paratypes NMW.Z.1981.118.00227; one paratype LEEDM.C.1993.5.18470; one paratype MRAC 507) (BMNH accession book states 'presented by the subscribers to the Fernando Po Exploration Fund namely Duke of Bedford, Walter Rothschild and Percy Sladen') (specimen could not be found at BMNH).

Pseudachatina striata Pain & Paul 1967d: 58, t. 5, fig. 3. Holotype: S. Cameroon, near Efulens, collector not stated, BMNH 1904.12.13.15 (one paratype NMW.Z.1981.118.00228) (BMNH accession book gives collector as G.L. Bates).

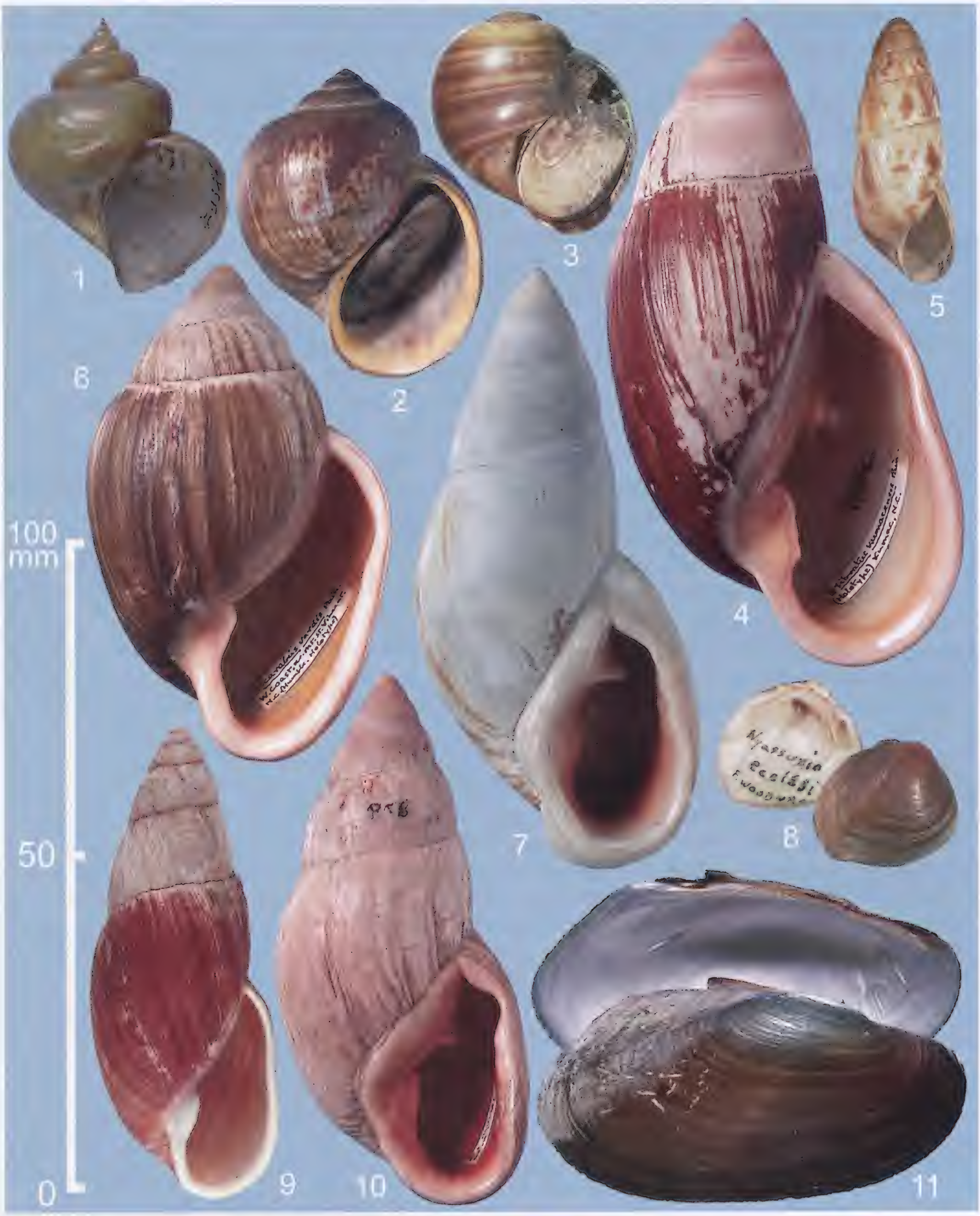
Pseudachatina wrighti (G.B. Sow. sen.) forma **minor** Pain & Paul 1967d: 48, t. 4, fig. 2. Holotype: Nigeria, Old Calabar, collector not stated, NMW.Z.1981.118.00149 **(fig. 18)** (two paratypes NMW.Z.1981.118.00229; one paratype LEEDM.C.1993.5.18473; one paratype MRAC 503)

Saulea lithoides Pain & Beatty 1964h: 2, t. 2/A, B, C. Holotype: Kenya, Kirimon Miocene deposits, *Patterson*, MCZ 28018.

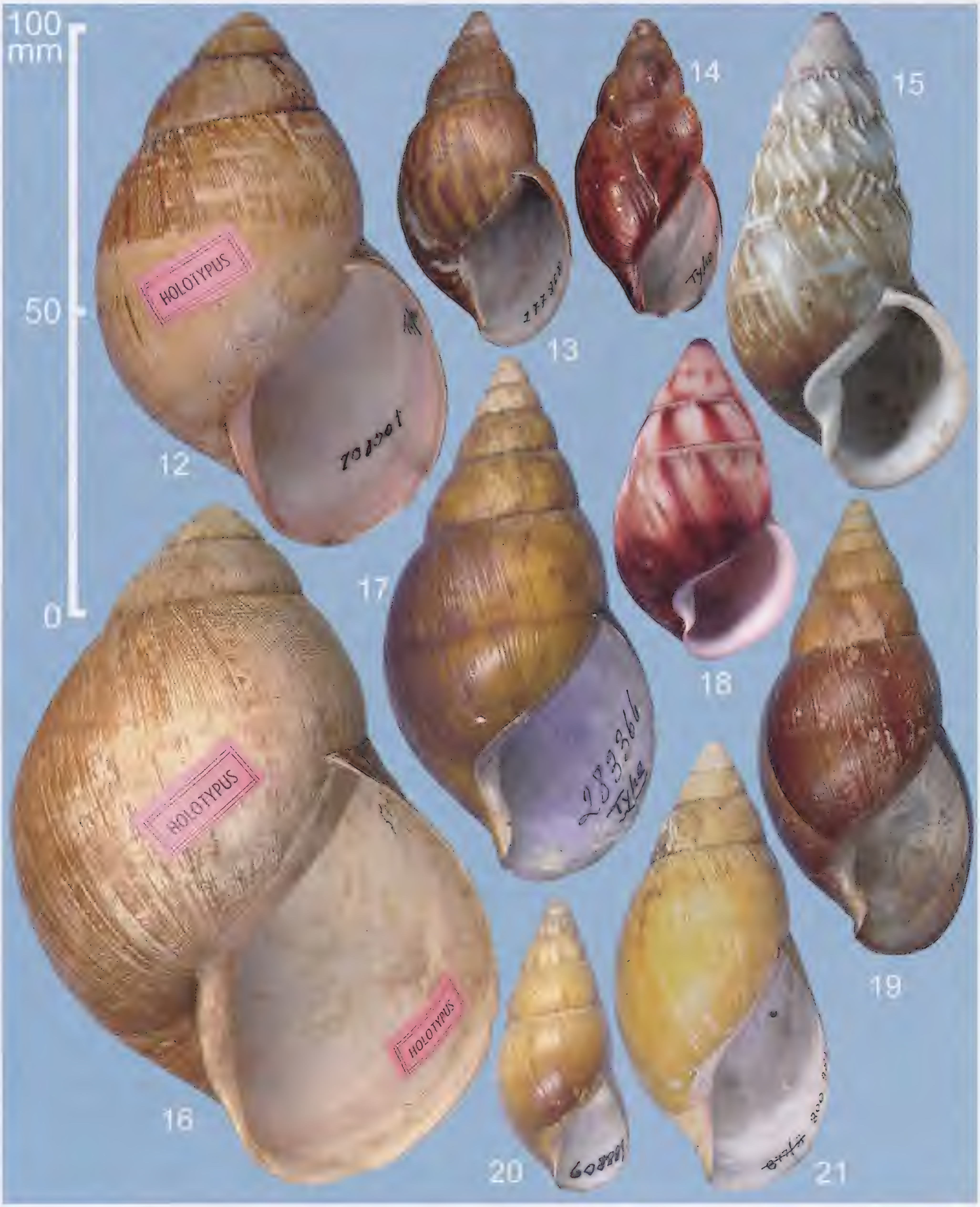
Museum abbreviations:
BMNH = Natural History Museum, London, England
IRSN = Institute Royal des Sciences naturelles de Belgique, Belgium
LEEDM.C. = Leeds Museum Resource Centre, Leeds, England
MCZ = Museum of Comparative Zoology, Harvard, USA
MMUM = Manchester Museum, University of Manchester
MRAC = Musée Royal de l'Afrique Centrale, Tervuren, Belgium
NMK = National Museum of Kenya, Nairobi, Kenya
NMSZ = National Museums of Scotland, Edinburgh, Scotland
NMW = National Museum of Wales, Cardiff, Wales pre 1970
NMW.Z. = National Museum of Wales, Cardiff, Wales post 1970
RMNH = Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands

B. Verdcourt[1]
A.H. Wood[2]
B. Rowson[2]

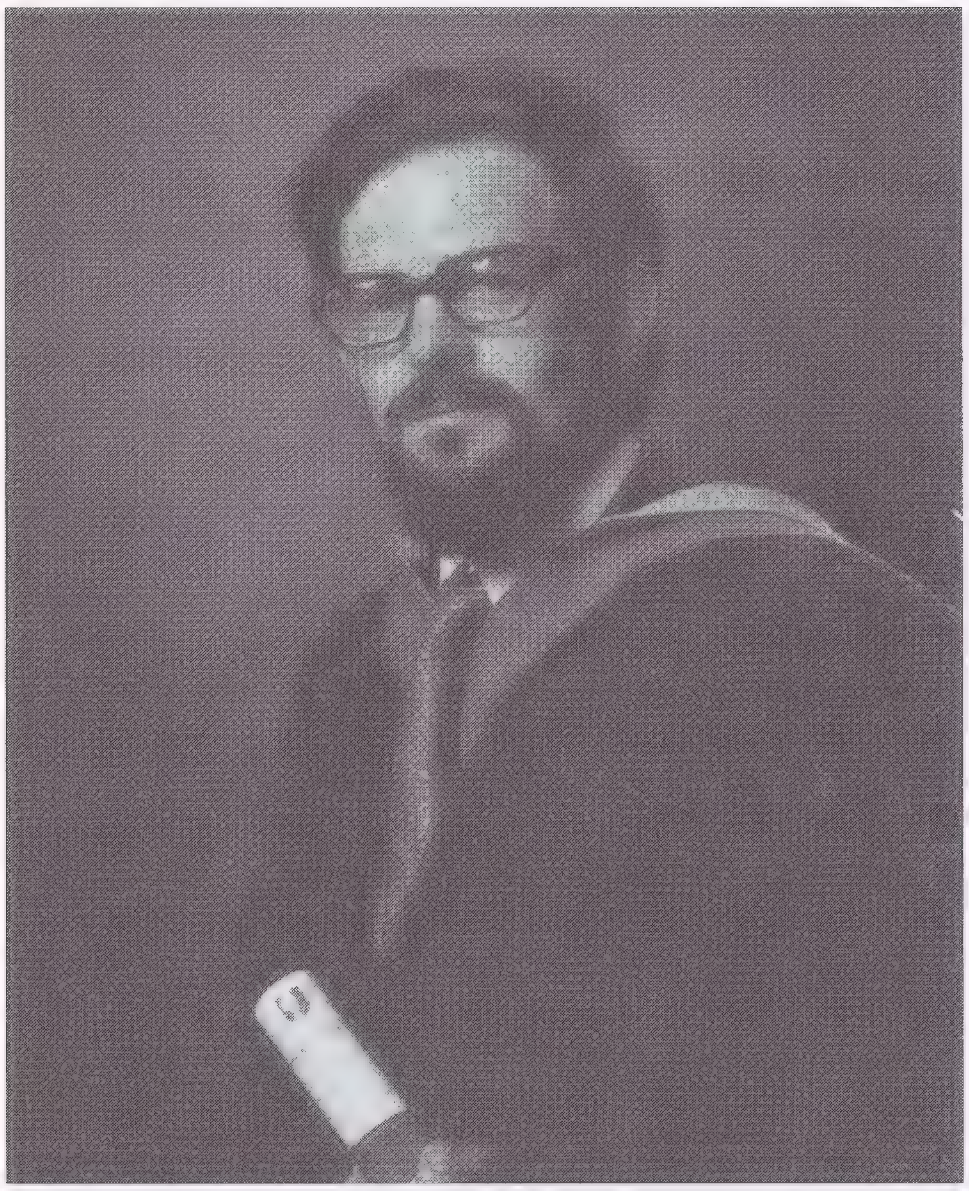
[1] Royal Botanic Gardens Kew, London
[2] National Museum of Wales, Cardiff



Figs 1-11 Holotypes of some of the new taxa described by Tom Pain. **1** *Neothauma ecclesi* (MRAC.793221; 45mm). **2** *Pomacea (Limnopomus) meridaensis* (NMW.Z.1981.118.00109; 49mm). **3** *Pila ovata dartevellei* (MRAC.36662; 38.5mm). **4** *Placostylus fibratus kumacensis* (NMW.Z.1981.118.00220; 100mm). **5** *Limicolariopsis cylindrica* (MRAC.793488; 43mm). **6** *Placostylus scarabus verdis* (NMW.Z.1981.118.00223; 74.5mm). **7** *Placostylus fibratus powelli* (NMW.Z.1981.118.00224; 91mm). **8** *Nyassunio ecclesi* (MRAC.793224; 21mm). **9** *Placostylus strattoni* (MMUM; 73mm). **10** *Placostylus fibratus mosesi* (NMW.Z.1981.118.00221; 82mm). **11** *Pleiodon waterstoni* (collection NMSZ. 1961.61.32801; 69mm).



Figs 12-20 Holotypes of some of the new taxa described by Tom Pain. **12** *Burtoa nilotica benoiti* (MRAC.101001; 91mm). **13** *Archachatina (Tholachatina) altitudinaria* (MRAC.277868; 62mm). **14** *Archachatina (Tholachatina) bequaerti* (MCZ.235271; 51mm). **15** *Pseudachatina connectens plicata* (NMW.Z.1981.118.00225; 88mm). **16** *Burtoa nilotica congoensis* (MRAC.5072; 116mm). **17** *Achatina (Achatina) bandeirana mayumbensis* (MRAC.283366; 90mm). **18** *Pseudachatina wrighti minor* (NMW.Z.1981.118.00149; 57mm). **19** *Achatina (Achatina) bandeirana arenaria* (MRAC.185116; 81mm). **20** *Limicolariopsis ellisi* (MRAC.608889; 54mm). **21** *Achatina (Lissachatina) mulanjensis* (MRAC.800985; 81mm).



OBITUARY: COLIN GILLARD, BA, CERT ED., 1935-2003

Colin Gillard joined the Conchological Society in 1989 and was elected as its Honorary Secretary at the Annual General Meeting in March 2000. Ill health forced Colin to resign the secretaryship in early 2002.

It is not known when Colin first became interested in molluscs but in the 1960s he measured snails' climbing ability on trees near his home at Rode. He marked the shells with paint, and marked where they were on the bark. Then, at night he climbed the trees and measured how far the individuals had travelled. After Colin joined the Conchological Society in 1989, he became an enthusiastic attender and leader of meetings. He organised the Mollusc Mapping of the County of Somerset from 1991 as a project within the Somerset Invertebrates Group and, as a preparation for those who would follow him ensured that the cards for sites, for tetrads, for 10km squares and the card index, floppy disks and box files were all up to date, ready for hand-over. His organisational skills for field meetings involved making everything as clear as possible with maps and mapping grids, timetables, copious annotations and directions to all the different locations.

As Honorary Secretary he was meticulous, prompt and unfailingly good humoured even when coping with the progress of his illness.

But there is much more to Colin than that.

He was born in Barnstaple, North Devon on 4th March 1935. His father died when Colin was 12 but he had a protective elder brother. He was educated at Barnstaple Grammar School. From school he went to do National Service as a conscript in the RAF, eventually becoming a fitter, stationed at Gosport. After National Service he went to Newlands Teacher Training College and then got his first post at Dulverton Primary School. While there he first met Margaret Astell at a Parish Breakfast in Barnstaple. They were married in Blackpool in 1960 and initially lived in Rode, both getting teaching posts in Frome. Colin then got the post of Headmaster of the Primary School at West Buckland, where they lived in the school house. Their two sons, Mark and Peter were born at Rode in 1962 and 1963 and were educated in Wellington. Later the family moved to Court Farm, Hillfarrance.

Colin then took a break from teaching to become Primary Schools Science Advisor in Milton Keynes for one year, and next adopted a self-sufficient way of life on their one acre at Hillfarrance with Margaret continuing to teach in Taunton. He had two posts as Assistant Warden at Stow and Crowcombe Youth Hostels, followed by Supply Teaching and then had full-time teaching, finishing up as Head of Maths at Dulverton Middle School for ten years, retiring in 1992.

Being very energetic Colin found time to: gain a BA degree at the Open University; take courses in mountain leadership and caving (Margaret similarly qualified); use these skills; take part in amateur dramatics; be a churchwarden and a bell-ringer, and look after his small holding.

A well-loved humorous enthusiast with a gift for cheering up all who came into contact with him. We miss him very much.

Colin is survived by his wife, Margaret, and sons, Mark and Peter and we extend to them our deepest sympathy.

Tony Smith

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

REPORT OF THE COUNCIL 2002

Council Positions

Dr Rundle began his third year as President of the Society. All Society Officers were re-elected. New Ordinary members of Council were Dr Aldridge, Mr Llewellyn-Jones and Dr Seddon. Mr Dansey, Miss Fogan and Mr Killeen began their second year and Dr Alexander, Ms McIvor and Mr Carr began their third year.

Publications

Two issues of the *Journal of Conchology* (Volume **37**: 5-6) and four issues of the *Conchologists' Newsletter* (Volume **10**, Numbers 160-163) were published. The last issue contained the index to the volume. The Society also published the Annual Programme Card and the Members' Guide. The Society website www.conchsoc.org was updated.

Other Council Matters

Six Council meetings were held and in addition there were two meetings of the Publications Committee.

Amongst the issues raised by Council were the Society's investments, insurance, the preparation of *Mollusc World*, grant applications, the Joint Meeting with the Malacological Society of London on Recording Molluscan Diversity, the Society Business Plan, and the Invertebrate Conservation Trust. Grants were awarded to: Mr Adrian Norris at Leeds City Museum for the 'Slime' exhibition (£600); Mr George Speller, PhD student at Cambridge University for Holocene molluscan successions in Ireland (£394); Dr Robert Briers, of the University of Wales, Aberystwyth, for geographical range limits and trematode parasitism in freshwater molluscs (£278.30); Mr Paul Craze for travel costs to Malaysia for field study of sympatric variation in shell coiling polymorphism in the S.E. Asian land snail *Amphidromus martensi* (£813); Ms Fiona Gill from Leeds University to study fossil cold seeps from the Caribbean (£500). £15 was also donated to the Invertebrate Trust.

I would like to thank all members of Council for their contributions during the year and express my appreciation of the excellent order in which the late Mr Colin Gillard handed over the Secretarial business following his resignation due to illness.

Rosemary Hill
Hon. Secretary

PROGRAMME SECRETARY'S REPORT - MARCH 2003

The programme for 2002 consisted of six indoor meetings held at the Natural History Museum in London, one indoor meeting at the Leeds Museum Resource Centre, one symposium at the National Museums and Galleries of Wales in Cardiff, five field meetings, one field workshop and and two indoor workshops.

Lectures at indoor meetings were given by Paul Davies (Small scale spatial and temporal aspects of molluscan ecology and palaeoecology), Trevor Coote (The French Polynesian endemic tree snail project), Adrian Rundle (Presidential address: Marine Mollusca in microfossil samples - an introduction), Ron Carr (The genus *Rumina*) (short talk), Peter Topley (Breeding *Achatina reticulata* in captivity) (short talk), Ron Boyce (Some observations on locomotion in slugs) (short talk), Kevin Brown ('She sells sea shells' by Veronica P. Johns (1968) – an extract) (short talk), Ian Killeen & Jan Light (Marine gastropods of Rodrigues), and Stephan Müller (The Asian clam in Britain - not as bad as we thought?).

An indoor meeting was held at the Leeds Museum Resource centre in Yeadon to view the molluscan collections held there.

A joint meeting with the Malacological Society of London was held at the National Museums and Galleries of Wales in Cardiff. Papers were presented by Frederic Magnin (Quantifying both land snail diversity and factors that can influence it in Mediterranean landscapes), Robert Cameron (How reliable are our estimates of land mollusc species richness? Scale, statistics and plain common sense), Alex Menez (Towards a standardized protocol for land mollusc sampling: molluscan ecology in south Iberia), Mary Seddon, Dai Herbert & Peter Tattersfield (The limitations of small sample size and Biodiversity Indices from land-snail surveys in South Africa), David Aldridge (Quantitative survey techniques for investigating freshwater mussel distributions), Andy Mackie (BioMor Surveys: results from benthic marine sampling programmes in the Irish Sea), Ian Killeen & Jan Light (Methods for assessing the marine mollusc microfauna of Rodrigues), Paul Davies (Assessing the small-scale spatial distribution of Mollusca: implications for conservation), Beata Pokryszko (What can a snail do to the reliability of our results?), and Dinarzarde Raheem & Fred Naggs (Sri Lanka: patterns of snail diversity); there were 4 poster presentations.

Field meetings were held at the following venues: Walton on the Naze, Essex (fossil meeting, Leader: John Llewellyn-Jones), Sandwich, Kent (Leader: Eric Philp), North Worcestershire (Leaders: Ron Boyce and Rosemary Hill), Loch Skeen, Dumfries & Galloway (Leader: Peter Dance), and Laxton, Nottinghamshire (Leader: Chris Du Feu), A sixth field meeting combined with a marine workshop (Tutors: Jan Light and Ian Killeen) was centred on Camborne in Cornwall where full laboratory facilities were available and samples from a range of marine field sites could be processed and identified.

A workshop on marine bivalves was held at the Reading Museum Resource Centre (tutor June Chatfield).

The Society's sixteenth Molluscan Workshop was on the subject of modern and fossil Pyramidellids, held at Judith Nelson's home in Woking, Surrey (tutor Adrian Rundle).

The Society is grateful to all those people who contributed to the above programme, as speakers, field meeting leaders, and meeting and workshop organisers and tutors.

Ron Boyce
Hon. Programme Secretary

FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2002

Statement of Financial Activities

	Note	2002	2001
Incoming resources			
Fees and subscriptions		**£9,820**	£10,360
Investment income	1	**£6,448**	£5,137
Income from activities for generating funds		**£535**	£413
Other incoming resources		**£0**	£15
Donations and legacies		**£98**	£19,177
Total incoming resources		**£16,901**	£35,102
Expenditure			
Publications costs		**£15,147**	£11,125
Stationery and postage		**£1,070**	£1,094
Meetings costs		**£874**	£1,620
Sundry expenses and fees		**£697**	£689
Grants	2	**£2,600**	£3,691
Depreciation		**£600**	£600
Total expenditure		**£20,988**	£18,819
Net incoming/(outgoing) resources		**-£4,087**	£16,283
Losses on revaluation & disposal of investment assets		**-£3,916**	-£4,220
Net movement in funds		**-£8,003**	£12,063
FUND BALANCES BROUGHT FORWARD		**£119,225**	£104,402
TRANSFER OF LIFE MEMBERSHIP FUND TO GENERAL FUNDS		**£0**	£2,760
Fund balances carried forward		**£111,222**	£119,225

Balance Sheet at 31st December 2002

	Notes	**2002**	2001
Fixed Assets			
Tangible assets	3	**£600**	£1,200
Investments	4	**£76,909**	£84,521
Total fixed assets		**£77,509**	£85,721
Current Assets			
Debtors	5	**£804**	£1,072
Cash at bank and in hand		**£41,335**	£39,603
Total current assets		**£42,139**	£40,675
Short term creditors	6	**£8,130**	£6,885
Net current assets/(liabilities)		**£34,009**	£33,790
Total assets less current liabilities		**£111,518**	£119,511
Provisions for liabilities	7	**£296**	£286
Net assets		**£111,222**	£119,225
Unrestricted income funds		**£111,222**	£119,225
Total funds		**£111,222**	£119,225

NOTES TO THE FINANCIAL STATEMENTS

ACCOUNTING POLICIES

General

- These statements have been prepared in accordance with Financial Reporting Standard for Smaller Entities (FRSSE) and the Charities SORP (Statement of Recommended Practice)
- Investments are valued at market value on 31st December.
- No trustee has received any remuneration during the current or previous year. Expenses incurred on behalf of the Society have been reimbursed.

Funds

- All Society funds are unrestricted funds
- The Life Membership Fund has been incorporated in the general funds, as it is an unrestricted fund. This is in accordance with the Charities SORP
- The accounts include transactions, assets and liabilities for which the Charity can be held liable.

Note 1. Investment income from:	**2002**	**2001**
Stock listed on recognised stock exchange	£6,087	£4,610
National Savings Income Bond	£361	£527
Total	£6,448	£5,137

Note 2. Grants awarded:	**2002**	**2001**
"Slime" Exhibition	£600	£2,155
Research grants to 5 individuals	£2,000	£1,536
	£2,600	£3,691

Note 3. Tangible fixed assets:	
Cost of computer	£3,000
Depreciation on straight line basis over 5 years	
Accumulated depreciation brought forward	£1,800
Charge for the year	£600
Balance of depreciation carried forward	£2400
Net book value carried forward	£600

Note 4. Investments:	**2002**	**2001**
Market value at beginning of year	£84,521	£88,740
Add: additions at cost	£37,472	
Less: carrying value of investments sold	(£41,168)	
Net loss on revaluation	(£3,916)	(£4,219)
Market value at end of year	£76,909	£84,521

Note 5. Analysis of debtors:	**2002**	**2001**
Tax debtors	£804	£940
Other debtors	£0	£132
Total	£804	£1,072

Note 6. Analysis of creditors and accruals:	**2002**	**2001**
Publications accruals	£4,525	£4,348
Meetings costs	£2,400	£1,600
Subscriptions in advance	£1,205	£937
Total	£8,130	£6,885

Note 7. Provision for liabilities:	**2002**	**2001**
Marine fieldwork provision	£296	£286
Total	£296	£286

Pryce Buckle
Honorary Treasurer

N. Light
Honorary Examiner

RECORDER'S REPORT: NON-MARINE MOLLUSCA

Access to the countryside was regained for 2002 following the end of the foot and mouth epidemic. Urban and garden sites continued to feature in recording, with their additional introduced species. It was good to see a quantity of records from Scotland and its islands, a part of the country less visited, or lived in, by recorders.

Many of the records coming in to the scheme have arisen out of survey contracts for wildlife trusts, other conservation bodies, local authorities and Government agencies. The European Habitats Directive, national county and local Biodiversity Action Plans are requiring more and up-to-date information on habitats and the assemblage of species they support as well as more information on Red Data Book species that are perceived to be threatened (Bratton 1991). Commissioned fieldwork with permission for access negotiated with landowners, and focussed on a particular habitat, has added many new records of the rarer species like Desmoulin's Snail (*Vertigo moulinsiana*). However, most species that are in the Red Data Book are habitat specialists depending on a narrow range habitat, like wetland, that is often under threat from human activities. Thus recording and mapping is a vital tool for conservation, in additional to its role as a study in biogeography.

Recording focussed on threatened species is being undertaken by consultants and university researchers for the rare Whorl Snails (*Vertigo*) (Moorkens 2003), the small Fine-lined Pea Mussel (*Pisidium tenuileatum*) and the larger freshwater mussels, including the uncommon Depressed River Mussel (*Pseudanodonta complanata*).

INTRODUCED SPECIES

The recently published atlas of British vascular plants (2002) demonstrated the increasing importance of introduced and naturalised alien plants that are becoming a constant part of our flora in countryside and towns. Greater movement of people and goods together with recent changes in climate have been instrumental in bringing about these introductions and their subsequent survival. A similar trend of increase in introduced species, that often spread very fast, has also been noted in non-marine molluscs. Slugs like *Deroceras panormitanum* and *Boettgerilla pallens* that spread in the 1960s to 1980s and more recently *Arion flagellatus* and *Lehmannia valentiana* (Kerney 1999) persist and continue to expand, while the Girdled Snail *Hygromia cinctella* frequently features in records from gardens and waysides for the southern half of the country. A project with school children is being run from the National Museums and Galleries of Wales (Cowell 2003).

Introduced species also occur in freshwater. The British distribution of the Zebra Mussel *Dreissena polymorpha* was studied in the 1960s (Kerney and Morton 1970) and is currently being reviewed by Paul Elliott at the University of Cambridge (Elliott 2003). He has been through the existing database of the Non-marine Recording Scheme and it will be interesting to see how the distribution and population levels have changed. The Zebra Mussel has the potential for high reproduction and dispersal through a pelagic larval stage and is a pest in pipes, thus research is likely to be funded. A more recent freshwater introduction is the Asian Clam *Corbicula fluminea* that was recorded in the UK in the River Chat of the southern Norfolk broads in 1990 (Roy Baker *pers. comm.*) and it has since increased in numbers and range. A native of eastern Asia, the clam established in the USA in 1957, appearing along the Rhine in Europe in the late 1980s and is now in Britain. Recorders should look out for this species.

NEW VICE-COUNTY RECORDS

Cornwall (2) *Lymnaea stagnalis* in vegetation on banks of Bude Canal, north-east of

Helebridge. Geraldine Holyoak, 13.07.2002.

South Devon (3) *Pisidium tenuileatum* in fine sediments in River Axe, Weycroft, near Axminster SY/306998, M J Willing 28.06.2002 and Bow Bridge, Axminster SY/290982. M J Willing 30.6.2002, both records confirmed by I J Killeen.

Merionethshire (48) *Hippeutis complanatus* in shallow water of Llyn Tegid (Bala Lake), SH/889320. M J Willing [2002].

East Donegal (H34) *Gyraulus laevis* in large weedy ditch, Inch Level. Geraldine Holyoak 13.08.2002; *Succinea putris* living in tall grasses and herbs on bank of large weedy ditch, Inch Level. Geraldine Holyoak 13.08.2002.

West Donegal (H35) *Planorbarius corneus* in shallow water on north-east side of Lough Fern. Geraldine Holyoak, 05.08.2002. *Vertigo lilljeborgi* in short fen vegetation of lake shore flood zone, Lough Fern, Near Moylehill. Geraldine Holyoak, 05.08.2002.

This is my last report as Non-marine Recorder, a post that I only agreed to take over for a short interim period. My successor will be Geraldine Holyoak who has been a very active recent recorder in Cornwall and Ireland, submitting many of the new Vice-county records in the last two reports. It is a pleasure to thank the recorders who have submitted field cards in the last two years.

June E Chatfield

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MOORKENS E. 2003 News from Ireland: workshop on the conservation of protected *Vertigo* species *Mollusc World* **1**: 6.

RECORDER'S REPORT: MARINE MOLLUSCA

Last year was characterised by records for some rarely recorded species. Barely into the New Year, Doug Herdson of the National Marine Aquarium at Plymouth reported that on January 3rd a fishing boat working in water depths of 770m due west of St Kilda hauled its nets aboard with some 3.5 tonnes of demersal fish including assorted commerical fish species and one giant squid. It was identified as a female *Architeuthis dux* with a total length of 3.3m to the tips of the arms. (Estimated length including tentacles, which were missing, would be 5.5m). The animal was frozen pending further work to assess its age (from the statoliths) and to carry out DNA analysis in order to elucidate its taxonomic status in relation to the 19 described species of *Architeuthis*. Experts believe there are no more than 7 species and some think there may only be 3, including *A. dux*.

Later, in September, at the other extremity of these islands, two specimens of *Charonia lampas* were taken, again by a commercial vessel, the 'Comley', skippered by Robert Greenwood. The animals were living at the mouth of the River Fowey in Cornwall at the time of their capture and were taken to the Mevagissey Aquarium. One snail was larger than the other giving rise to the supposition that a male and female had been taken and this was confirmed when the larger of the snails laid eggs. The snails survived for some months but died in January during a bout of exceptionally cold weather when the Aquarium was closed to the public. The eggs did not hatch. *Charonia lampas* was first recorded from these islands, in Irish waters, in 1970/71 and from Cornwall in 1975. There have been sporadic records since that time and animals have been kept for extended periods in the Aquarium at Plymouth.

In June large numbers of the colonial hydrozoan, *Velella velella*, were washed up on the southwest coast of the Isle of Wight. According to local beachcombers and fishermen it was one of the largest strandings ever. Often beachings of *Velella* herald the arrival of their predator, namely *Janthina janthina*. On this occasion just two well preserved specimens of *Janthina* were found, one each from two sites on the south coast, and reported to the island's marine biological recorder, Roger Herbert. One specimen still had its float intact and these two finds double the total number of specimens found on Isle of Wight shores! Other news from the island indicates that after the catastrophic effects of the exceptionally severe winter of 1962/3 on the island's population of razor shells, *Ensis* species and *Solen marginatus*, the latter have started to recover to the extent that local fishermen are now salting for them between Ryde and Kings Quay.

Observations and information relating to less familiar species are often submitted by divers and by scientists conducting sublittoral surveys using ship-deployed sampling gear. The rare nudibranch, *Hancockia uncinata* was recorded during diving by Lin Baldock of Broadmayne on 22nd September in Poole Bay. Two specimens were found among a handful of mixed red algae tangled around a fishing line from a depth of 13m. There was a dense growth of the hydroid, *Clytia hemispherica* on the tangle and this is the food organism for *H. uncinata*. The specimens were not noticed until examination under microscope. Ivor Rees, of Bangor, spent 3 weeks on a research cruise in the English Channel. Amongst bycatch he noted specimens of *Simnia patula*, which feeds on the soft coral *Alcyonium digitatum*, from benthic samples taken from water depths of 70-80m off Start Point in Devon.

Microgloma pusilla (Jeffreys 1879) and *Notolimea clandestina* Salas 1994 are microscopic bivalves known from deep European waters and the Strait of Gilbraltar respectively. In *Basteria* (2002, **66:** 193-196) Dick Hoeksema has reported shells of these marine bivalves in beach-collected shell gravel from beaches in southwest Netherlands. The *M. pusilla* shell is believed to be Recent but the *N. clandestina* valves are described as fossil. These records are the first from the shallow waters of the southern North Sea Basin.

The Field Workshop which took place in October at Godrevy, Cornwall represents a new approach to the Society's activities. An illustrated account appeared in the first issue of ***Mollusc World***. The opportunity to work on samples whilst they were freshly collected enabled participants to understand small scale distributions of molluscs amongst the algal turf and to see and identify living examples of its microfauna, of which *Vitreolina philippi* was a highlight.

New records come in many guises. Last year saw the publication of a monograph on a group of bivalves which give rise to identification problems. *The Thyasiridae of the British Continental Shelf and North Sea Oilfields* by Graham Oliver & Ian Killeen deals with the twelve species found in shelf waters around the British Isles and in the North Sea, and others reported from adjacent regions. It gives a taxonomic review, provides keys, illustrates all species and their growth stages and covers intraspecific variation. It contains numerous new records of *Thyasira* species for sea areas within the Marine Census area. Although primarily applicable to the North Sea the monograph covers most of the taxa found in shelf waters of the Eastern Atlantic and Mediterranean and to some extent the north west Atlantic.

The Society is planning a series of projects targeted at species and groups of species, over the coming years. Two marine species to receive attention will be *Crepidula fornicata* and *Osilinus (Monodonta) lineata*. I hope members will support these initiatives and other recording activities. I thank all members who continue to support the Society's marine recording scheme.

Jan Light

REPORT OF THE HON. CONSERVATION OFFICER 2002-2003

Selected key items from the 2002 - 03 year are summarised below.

Advice and help

Has been given to many individuals and organisations and some examples include:

- The Hampshire Biodiversity Records Centre (HBIC) has been supplied with Hampshire records for a suite of BAP and RDB species. Information held will be used by partners of the HBIC (e.g. the Hampshire Wildlife Trust and the Environment Agency) to allow informed site management decisions throughout the County.
- Ferring Parish Council were given advice and information on the distribution of *Monacha carthusiana* in relation to lands lying on the boundary of the proposed South Downs National Park.
- West Sussex County Council was given information on the mollucan importance of South Downs woodlands lying close to the River Arun.
- Specimen identification, advice and contacts were given to a worker undertaking surveys on *Lymnaea glabra* populations on Herefordshire Nature Trust reserves.
- The manager of the RSPB, Wolves and Ramsey Woods reserve in Suffolk was advised on survey possibilities for the wood and advice on management to retain rare woodland Mollusca.
- The Herts and Middlesex Wildlife Trust were assisted on the problem of a population of *Helix pomatia* becoming 'lodged' in a wire loop fence surrounding a reserve wood.
- Information, local contacts and advice have been sent to a conservation group managing calcareous grassland near to Newton Abbott in Devon.

British Wildlife

The production of a biannual molluscan wildlife report for this journal has continued. The Conservation Officer has used this column to publicise selected aspects of work undertaken by the Society. The June 2002 report was again able (as in 2001) to give a summary of some of the most interesting items appearing in the annual Recorders' reports. Later in the year publicity was given to a variety of other conservation work undertaken by Society members. Obtaining relatively current and topical news material has not always been easy in the production of this column; the Conservation Officer would particularly like to thank those members of the Society who responded to requests for news by supplying information that draws attention to the dynamic work undertaken by some Society members. Approaches have been made to British Wildlife for the inclusion of three Wildlife Reports annually; the newly issued *Mollusc World* should prove to be a valuable source of interesting and topical news for use in these British Wildlife reports. Every effort will be taken to publicise the Society through British Wildlife.

Invertebrate Link (formerly J.C.C.B.I.) and The Invertebrate Conservation Trust (Buglife)

Membership of the Committee continues providing valuable contacts with other organisations. The Conservation Officer and other Society representatives have attended all meetings. The Conchological Society is a corporate member of the Invertebrate Conservation Trust (or ICT, also to be known under the popular name 'Buglife'). An article appearing in the first issue of *Mollusc World* described the background and aims of this new invertebrate organisation. The ICT has provided a variety of conservation news items, reports and initiatives from the wider conservation world, that have been circulated to various council members. Selected items of interest or importance will also be used in the new 'Conservation News' columns of *Mollusc World*.

The Fourth Quinquennial Review of Schedules 5 and 8 of the Wildlife and Countryside Act, 1981

In early 2002 members of the Conchological Society Conservation Committee submitted recommendations to the Joint Nature Conservation Committee (the JNCC). The proposals suggested the addition of two species, the Roman Snail *Helix pomatia* and Witham Orb Mussel *Sphaerium solidum* to Schedule 5 of the Act, together with the removal of two others, the Lagoon Snail *Paludinella littorina* and the Northern hatchet-shell *Thyasira gouldi*. Later in 2002 the JNCC submitted advice to the Government regarding these proposals. These included the recommendation that *Helix pomatia* be carried forward for further consideration, which will involve consultation by Government with a wider range of organisations and individuals. It is intended that the Conchological Society will be able to play a full part in this process. The JNCC did not recommend *Sphaerium solidum* for further consideration. As no species are to be considered for removal from Schedule 5 until the Biodiversity Action Plan reviews are undertaken in 2005, then *Paludinella littorina* and *Thyasira gouldi* will remain on WCA schedules. Further developments regarding the Fourth Quinquennial Review will appear in *Mollusc World's* conservation news.

Biodiversity Matters

- Four Molluscan Conservation Group members continue involvement on UK BAP Steering Groups for a number of the Biodiversity Steering Group's Priority Species. Mollusca include (1) the terrestrial species: *Vertigo geyeri, V. genesii, V. angustior, V. moulinsiana* and *Catinella arenaria* and (2) the freshwater species *Pseudanodonta complanata, Pisidium tenuilineatum, Segmentina nitida, Anisus vorticulus* and *Myxas glutinosa.* Members of the two steering groups undertook to comment on and recommend additions/ amendments to UKBAP review process forms, which were completed at the end of 2002 (for further details visit: http://www.ukbap.org.uk). There was concern that the lead partner for *Anisus vorticulus* did not undertake this process, but the Environment Agency decided to retain their lead role and have another officer to take responsibility for the species. The Freshwater Steering Group met in Early April 2003, whilst that for the terrestrial species will meet in Belfast in June 2003. Summary details of both meetings will appear in *Mollusc World*.
- Several Society members have been involved on a professional basis with survey and monitoring work on Biodiversity Steering Group Priority Species including *Margaritifera margaritifera, Vertigo moulinsiana, V. geyeri, V. genesii, Myxas glutinosa*, and *Pisidium tenuilineatum.* Recently extended studies on the latter two species have been completed and papers will be submitted to the Journal as well as summary details included in *Mollusc World*. Work has also involved RDB species such as *Valvata macrostoma.*

Associations with other organisations

In April 2002 six members of the Society joined with a number of other malacologists from across Europe in Dublin at the Workshop on Conservation Biology of European *Vertigo* species. Further details appear in issue one of *Mollusc World*.

The Conservation Officer and Mr. I.J. Killeen attended the English Nature 'Species Recovery Programme' Eleventh Anniversary Conference in February 2002.

The Conservation Officer continues to attend conservation committee meetings of The Sussex Wildlife Trust. He wrote an article on rare molluscs and Sussex hanger woodlands for the *Adastra* magazine published annually by the Biological Records Centre of the Sussex Wildlife Trust. The article was able to draw attention to the Conchological Society and its website.

Other conservation News

The Society (together with representatives from Gloucestershire Wildlife Trust and Gloucestershire Naturalists' Society) has been involved in efforts to ensure that suitable habitat management allows the continued existence of *Lauria sempronii*. This RDB Category 1 (endangered) species is only known to live at one site in the UK. Negotiations have been underway with site owners since mid-2002, to ensure that the two old stonewalls supporting the snail are partially cleared of excess ivy.

Some years ago concern was raised that proposed developments near Kew would destroy or damage populations of the rare Thames door-snail *Balea biplicata* (RDB Category 3: rare). It has recently been learnt that the St. George Company, developers of Kew Riverside Park, have established a reserve on the site to ensure the snail's continued existence at Kew. Further details of these last two items will be reported in forthcoming editions of *Mollusc World*.

M.J. Willing
Hon. Conservation Officer

HON. MEMBERSHIP SECRETARY'S REPORT FOR 2002

Membership of the Society at the end of 2002 was 332. This includes Life Members, Honorary Members, Ordinary Members, Family Members, Student Members and Institutions. There were 27 new members in the year, but 18 members resigned or lapsed through non-payment, giving a net gain of 9 members for the year.

During the year there were 80 subscribers to the *Journal of Conchology* compared with 78 in 2001.

Mike Weideli
Hon. Membership Secretary

INSTRUCTIONS TO AUTHORS

Manuscripts should be sent to:

EDITORIAL ASSISTANT, A.M. HOLMES,
NATIONAL MUSEUMS & GALLERIES OF WALES, CATHAYS PARK, CARDIFF CF10 3NP.
ANNA.HOLMES@NMGW.AC.UK

PAPERS Two copies of text and illustrations should be submitted; one set of illustrations must be good quality originals. Authors should refer to *New Instructions to Authors* in 37 part 1. Authors are reminded of the high cost of printing and therefore are expected to write concisely and to make maximum use of page size when designing artwork and tables.

COMMUNICATIONS These are intended to be short notes of an original nature which do not merit the treatment of a full paper. *Communications* do not normally contain any figures, tables or plates and should conform in style to that of recent issues of the *Journal.*

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Biogeography and Taxonomy

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

Hon. General Secretary Miss R.E. Hill
447b Wokingham Road, Earley, Reading RG6 7EL

Hon. Treasurer Mr P.U. Buckle
14 Roughdown Road, Boxmoor HP3 9BJ

Hon. Membership Secretary Mr W.D. Weideli,
35 Bartlemy Road, Newbury, Berks. RG14 6LD

Hon. Editor (*Journal of Conchology*) Dr P.G. Oliver
National Museums & Galleries of Wales, Cathays Park,
Cardiff CF10 3NP

Hon. Programme Secretary Dr R. Boyce,
447c Wokingham Road, Earley, Reading RG6 7EL

Hon. Conservation Officer Dr M.J. Willing,
14 Goodwood Close, Midhurst, Sussex GU29 9JG

Hon. Marine Census Recorder Mrs J. Light,
88 Peperharow Road, Godalming, Guildford, Surrey GU7 2PN

Hon. Non-marine Census Recorder Mrs G. Holyoak,
8 Edward Street, Tuckingmill, Camborne,
Cornwall TR14 8PA

Hon. Editor (*Mollusc World*) I.J. Killeen
163 High Road West, Felixstowe, Suffolk IP11 9BD

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Meetings are held at the British Museum (Natural History) at 2.30pm usually on the third Saturday of each month from October to May. Field meetings are held in the summer.

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A NEW SPECIES OF *SCHILEYKIELLA* FROM MARETTIMO (AEGADIAN ISLANDS, ITALY) AND DISCUSSION OF RELATIONSHIPS OF CILIELLINE HYGROMIIDS (GASTROPODA, PULMONATA, HYGROMIIDAE)

S. CIANFANELLI[1], G. MANGANELLI[2] & F. GIUSTI[2]

Abstract A new species of Schileykiella, S. bodoni, *is described from Marettimo Island, one of the islands of the Aegadian archipelago. The new species is very similar to* S. parlatoris *but distinguished by: very short hairs on teleoconch; shorter vagina and epiphallus; penial flagellum with knob at base, near point at which vas deferens enters penis; knob corresponding to internal structure bordering vas deferens opening into penis.*

Schileykiella *is a genus of the hygromiids endemic to Sicily and peri-Sicilian islands, with shell pilose, cerebral penial innervation, right ommatophore retractor between penis and vagina, distal female genitalia without digitiform glands and dart-sac complex and distal male genitalia with penial sheath but without penial papilla. Some authors recently proposed that it belongs to the suprageneric group including* Ciliella, *e.g. the cilielline hygromiids. However this remains a hypothesis. In fact, apart from the very different composition of the lists of taxa included in the ciliellinae hygromiids there is no sure derived character supporting their monophyly.*

Key words Schileykiella bodoni *n. sp.*, Schileykiella, *Ciliellinae, taxonomy, systematics, distribution, Marettimo, Aegadian Islands, Sicily.*

INTRODUCTION

The genus *Schileykiella* Manganelli, Sparacio & Giusti, 1989, includes two species from Sicily with shell small, pilose, brown in colour, flat and contabulate or very low conical above, with a spire of 4-5 slowly and regularly increasing whorls, separated by deep sutures, umbilicus deep and wide and peristome not thickened. One species, *S. parlatoris* (Bivona, 1839), is widespread, occurring in NW and SE Sicily (Fig. 1) and reported from Gozo, one of the Maltese Islands; the other, *S. reinae* (Pfeiffer, 1857), is not widespread, occurring only in very few sites of NW and central Sicily (Fig. 2) (Manganelli *et al.*, 1989; Giusti *et al.*, 1995).

Shells similar in shape to those of the Sicilian *S. parlatoris* were recently collected on Marettimo, an island of the Aegadian archipelago close the NW coast of Sicily. However, these shells had short hairs, thus differing from Sicilian populations with very long hairs but identical to the single shell reported from Gozo.

In small xerophilous hygromiids, differences in hair structure and length have often been considered indicative of distinct species but the problem was ignored by Giusti *et al.* (1995) because the material from Gozo, consisting of only one shell, was obviously insufficient basis for any conclusion. We nevertheless began field work to collect live adult specimens on Marettimo. Two specimens were found with genitalia very similar to those of *S. parlatoris*, but characterized by certain details, which together with the shorter shell hairs, support introduction of the new species described herein. Some specimens of *S. parlatoris* recently collected in mainland Sicily were also dissected and their genitalia studied to enable a more detailed comparison with the new species and, if appropriate, to revise the diagnosis and description of *Schileykiella* by Manganelli *et al.* (1989).

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[1] Museo Zoologico de "La Specola", Sezione del Museo di Storia Naturale dell'Universitá di Firenze, Via Romana 17, I-50125 Firenze, Italy.

[2] Dipartimento di Scienze Ambientali, Universitá di Siena, Via Mattioli 4, 53100 Siena, Italy.

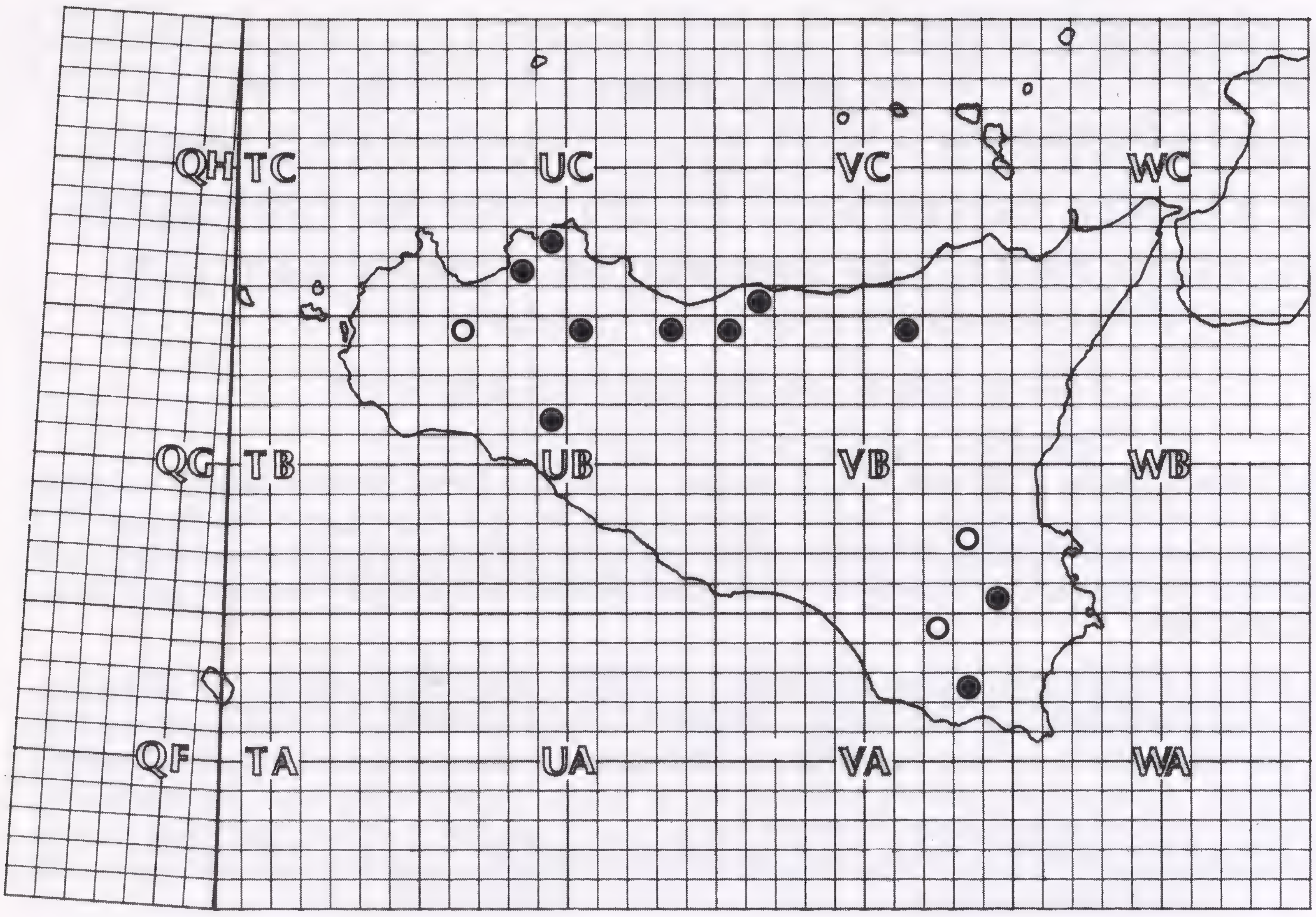


Fig. 1 Distribution of *Schileykiella parlatoris* (Bivona, 1839). Full dots: data collected after 1980; empty dots: historical data; for the list of localities, see Appendix.

MATERIAL AND METHODS

Whole shells were photographed under the light microscope (Wild M5A). Shell dimensions (number of whorls; shell diameter; shell height; umbilicus diameter) were measured with a micrometer. Hair dimensions were measured by SEM, using ADDA II hardware and AnalySIS 2.1 software, both by Soft Imaging System.

Live specimens were drowned in water, then fixed and preserved in 75% ethanol buffered with $NaHCO_3$. The bodies were isolated after crushing the shells and dissected under the light microscope (Wild M5A) using fine pointed watchmaker's tweezers. Anatomical details were drawn using a Wild camera lucida. Some parts of the genital organs (duct of bursa copulatrix, free oviduct, vagina, flagellum, epiphallus and penis) were measured by micrometer.

Radulae were extracted manually from the buccal bulbs, washed in pure 75% ethanol, mounted on copper stubs with electronconductive glue, sputter-coated with gold and photographed using a Philips 505 SEM.

The material examined is listed as follows: locality, municipality and province names in parenthesis, UTM reference, collector(s), date, number of specimens and collection where they are kept in parentheses. Locality names and UTM references are according to the official 1:50,000 scale map of Italy (series M 792).

Key to acronyms of museums and private collections: FCMC Fondazione Culturale Mandralisca (Via Mandralisca 13, 90015 Cefalù, Italy), MBC M. Bodon coll. (Via delle Eriche 100/8, 16148 Genova, Italy), FGC F. Giusti coll. (Dipartimento di Scienze Ambientali, University of Siena, Via Mattioli 4, 53100 Siena, Italy), MCSNM Museo Civico di Storia Naturale di Milano (Corso Venezia 55, 20121 Milano, Italy), MCSNV Museo Civico di Storia Naturale di Verona (Lungadige Porta Vittoria 9, 37129 Verona,

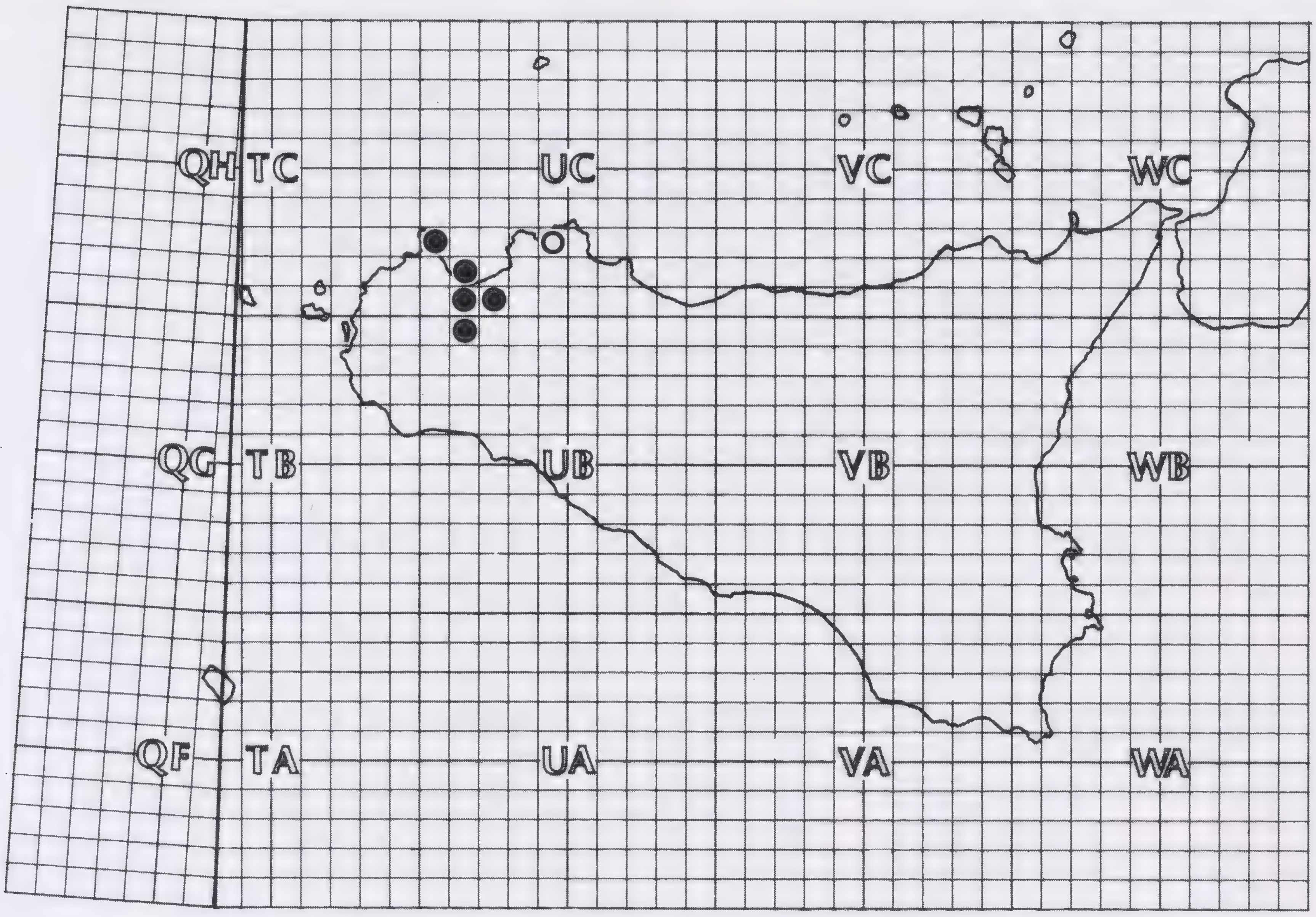


Fig. 2 Distribution of *Schileykiella reinae* (Pfeiffer, 1857). Full dots: data collected after 1980; empty dots: historical data; for the list of localities, see Appendix.

Italy), MCZR Museo Civico di Zoologia (Via Aldrovandi 18, 00197 Roma, Italy), MZUF Museo Zoologico "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze (Via Romana 17, 50125 Firenze, Italy), MZUT Museo di Zoologia dell'Università di Torino (Via G. Giolitti 36, 10123 Torino, Italy), SCC S. Cianfanelli coll. (P.le Porta Romana 13, 50125 Firenze, Italy).

Key to acronyms used in Figs 11-26: A atrium, BW body wall, DBC duct of bursa copulatrix, BC bursa copulatrix, E epiphallus, F flagellum, FK flagellum knob, FO free oviduct, FOO free oviduct opening, LLL left lateral lobe, LDL left dorsal lobe, RLL right lateral lobe, RDL right dorsal lobe, SL subpneumostomal lobe, POS prostatic portion of ovispermiduct, P penis, PN penial nerve, PPO proximal penis opening, PPP penial pseudopapilla, PR penial retractor, PS penial sheath, UOS uterine portion of ovispermiduct, V vagina, VD vas deferens, VDO vas deferens opening.

Schileykiella bodoni n. sp.

Type series Holotype from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001 (a shell, MZUF 20913) and 91 paratypes from Island of Marettimo, Pizzo Falcone 580 m, 33STC4107, S. Cianfanelli & E. Talenti leg. 5.6.1997 (1 sp, 22 sh, MZUF 20933), S. Cianfanelli leg. 10.11.2001 (2 sp, MZUF 20922; 65 sh., 20923), Pizzo Falcone, 33STC4107, V. Fiorentino leg. 6.11.2001 (1 sh, FGC no. 18758) and Punta Basano, 33STC4404, V. Fiorentino leg. 7.11.2001, (1 sh, FGC no. 18901).

Type locality Island of Marettimo, Pizzo Falcone (Favignana, Trapani), 33STC4107.

Identification A species of *Schileykiella* (a genus of the hygromiids endemic to Sicily and peri-Sicilian islands, with shell pilose, brown in colour, cerebral penial innervation, right ommatophore retractor between penis and vagina, distal female genitalia without digitiform glands and dart-sac complex and distal male genitalia with penial sheath,

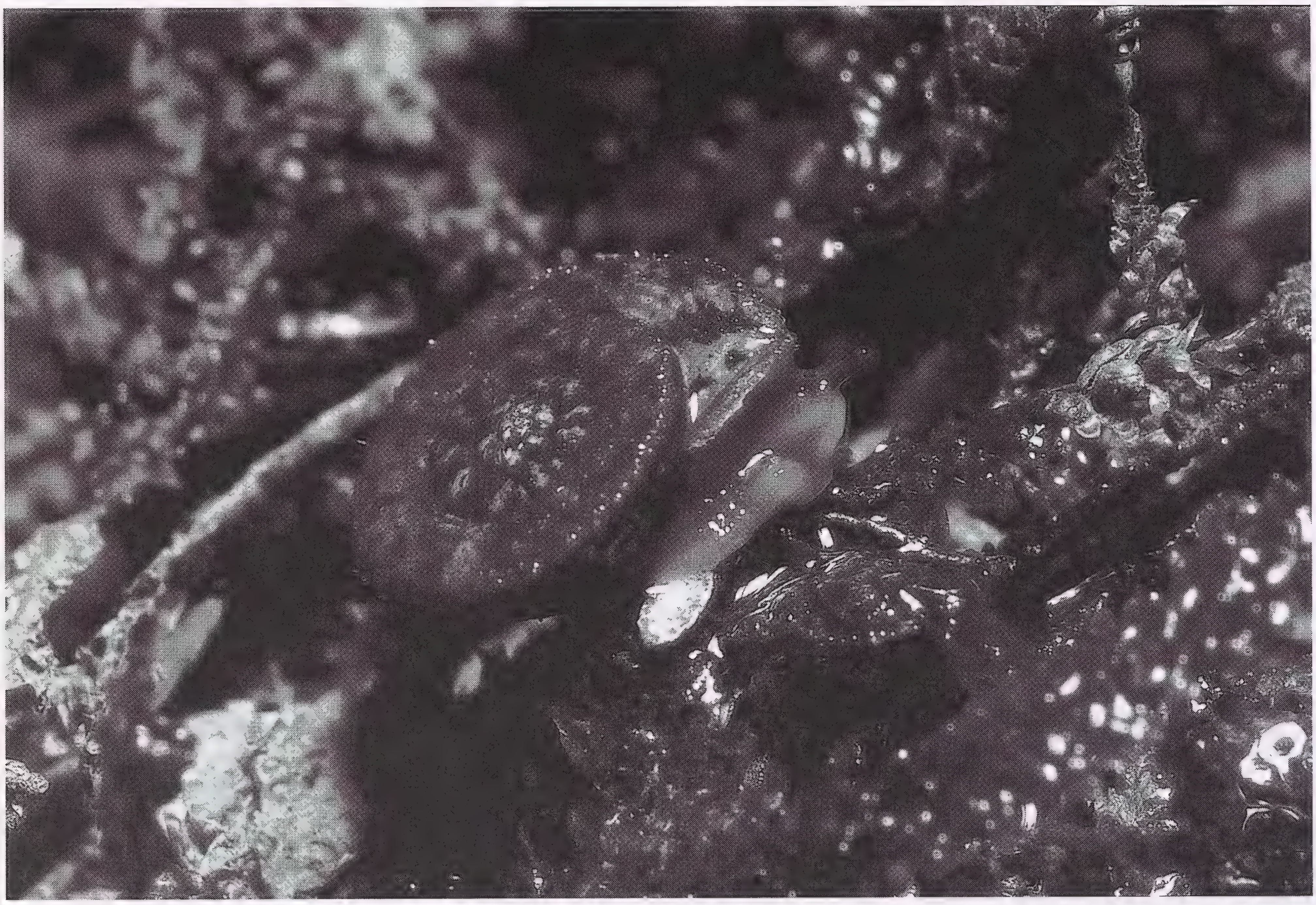
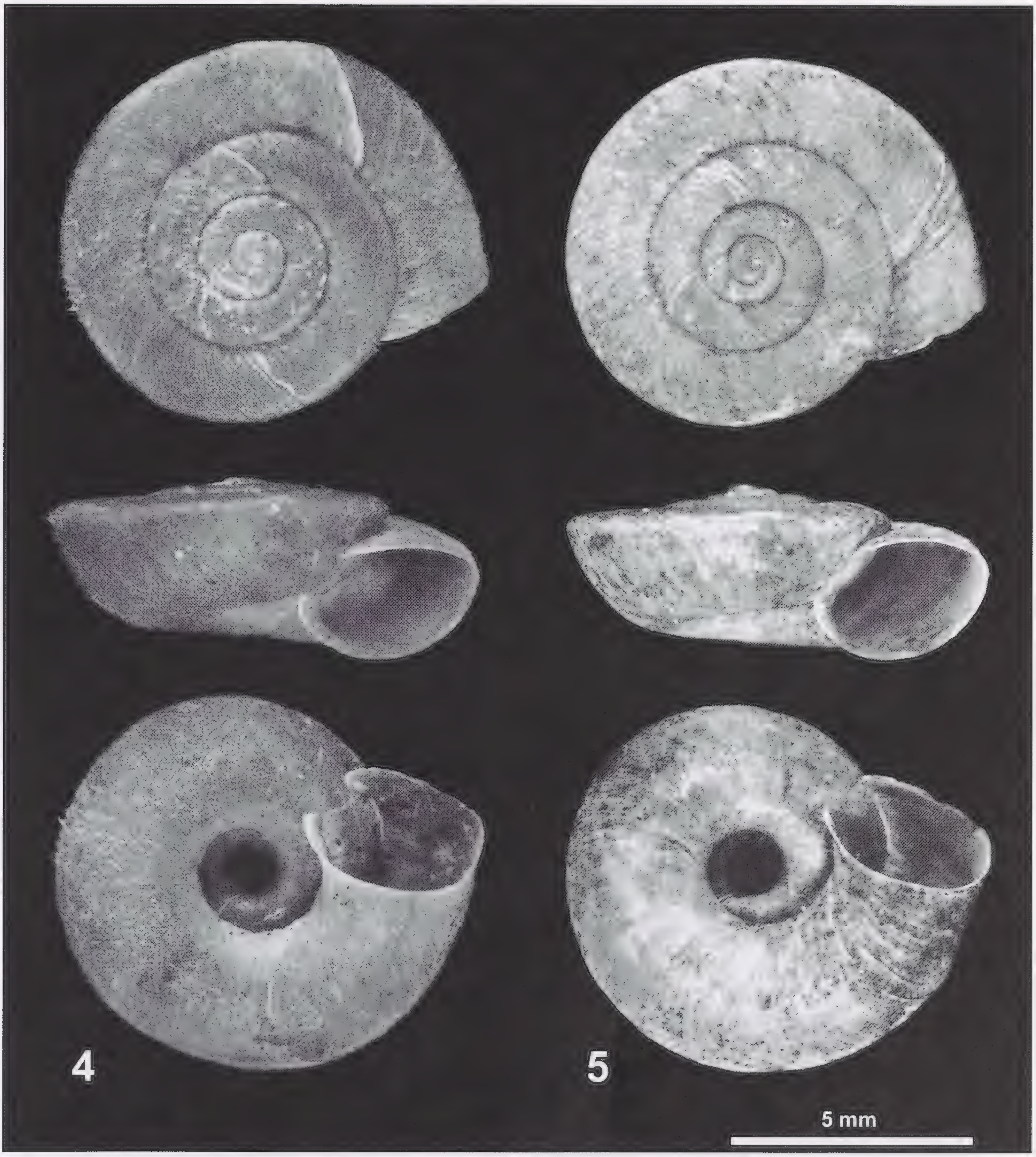


Fig. 3 Living specimen of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001.

but without penial papilla), characterized with respect to the most similar congener *S. parlatoris* by: very short hairs on teleoconch; shorter vagina and epiphallus; penial flagellum with knob at base, near point at which vas deferens enters penis; knob corresponding to internal structure bordering vas deferens opening into penis.

Description Body (Figs 3, 10) brown, darker on neck and sides, with tentacles blackish. Walls of pallial cavity and of visceral sac with variably large brown-black spots. Mantle border (Fig. 11) square in contour, well angled at left upper vertex (at shell angulation) with five lobes: dextral and left dorsal lobes bordering upper margin of pneumostome rather small; left lateral lobe very small, very far from left dorsal lobe; subpneumostomal lobe variable in shape, usually pyriform; dextral lateral lobe elongated triangular, with base situated below anal opening. Foot with non partite sole of holopode type. Penial nerve from right cerebral ganglion. Retractor of right ommatophore between penis and vagina. Sigmurethrous kidney. Jaw of odontognathous type.

Shell (Figs 1-2, 4-7) dextral, small, pilose, brown in colour, contabulate (whorls markedly angled so that, when they are raised, shell appears somewhat scalariform in frontal view), flat or very slightly raised above, convex-rounded below, with spire formed by 4 $^1/_4$ - 4 $^3/_8$ slowly and regularly increasing whorls separated by rather deep sutures; whorls markedly angled, shouldered, slowly and sligthly descending near aperture; umbilicus deep and wide $^1/_5$ - $^1/_4$ of shell maximum diameter; aperture oblique, angled at its external margin, pyriform to drop-like; peristome not thickened, slightly reflexed at its columellar margin; surface of protoconch with rather evident transverse striae and impressions of hair roots, with microsculpture consisting of very fine, longitudinal grooves; periostracal surface of teleoconch with transverse rows of hairs and minute longitudinal crests which are interrupted on areas coinciding with

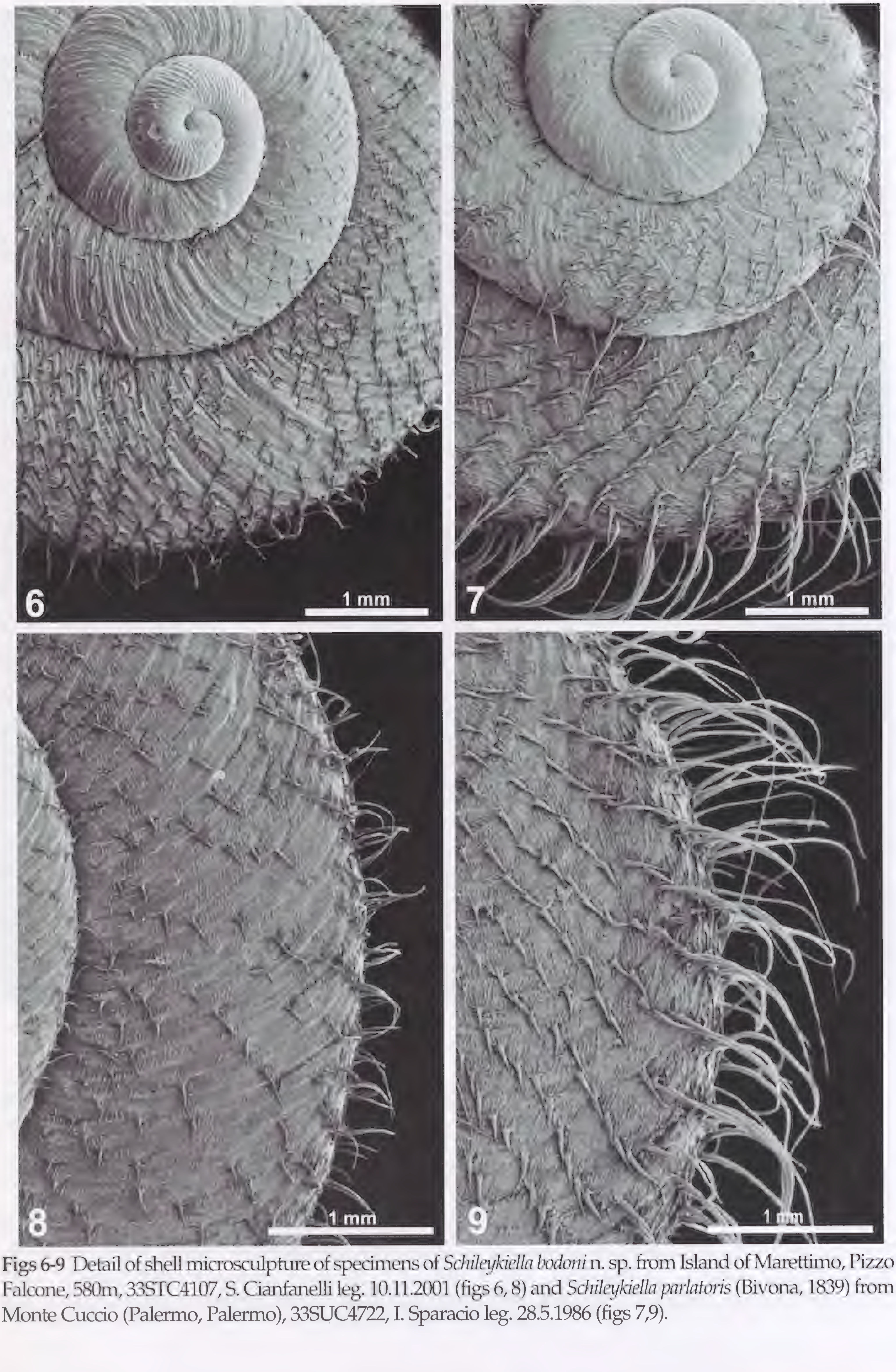


Figs 4-5 Two shells of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001, one (Fig. 4) designated as holotype.

growth lines on the first whorls and often also on the last whorl; hairs on upper surface of whorls form virtual rows slightly oblique with respect to growth line on which first hair of each row is situated (hair closest to suture); length of hairs increases from the sutures to the whorl periphery where it reaches maximum (0.26 - 0.28 mm), level with periphery of third whorl).

Dimensions (10 shells measured). Shell diameter: 8.2 ± 0.39 mm (7.2 - 8.6), height: 3.4 ± 0.20 mm (3.0 - 3.7), umbilicus diameter: 2.5 ± 0.18 mm (2.1 - 2.8), number of whorls: $4^{1}/_{6} \pm {}^{1}/_{9}$ (4 - 4 $^{1}/_{4}$).

Genitalia (Figs 10-16). General scheme of genitalia as in hygromiids (we only describe



Figs 6-9 Detail of shell microsculpture of specimens of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580m, 33STC4107, S. Cianfanelli leg. 10.11.2001 (figs 6, 8) and *Schileykiella parlatoris* (Bivona, 1839) from Monte Cuccio (Palermo, Palermo), 33SUC4722, I. Sparacio leg. 28.5.1986 (figs 7,9).

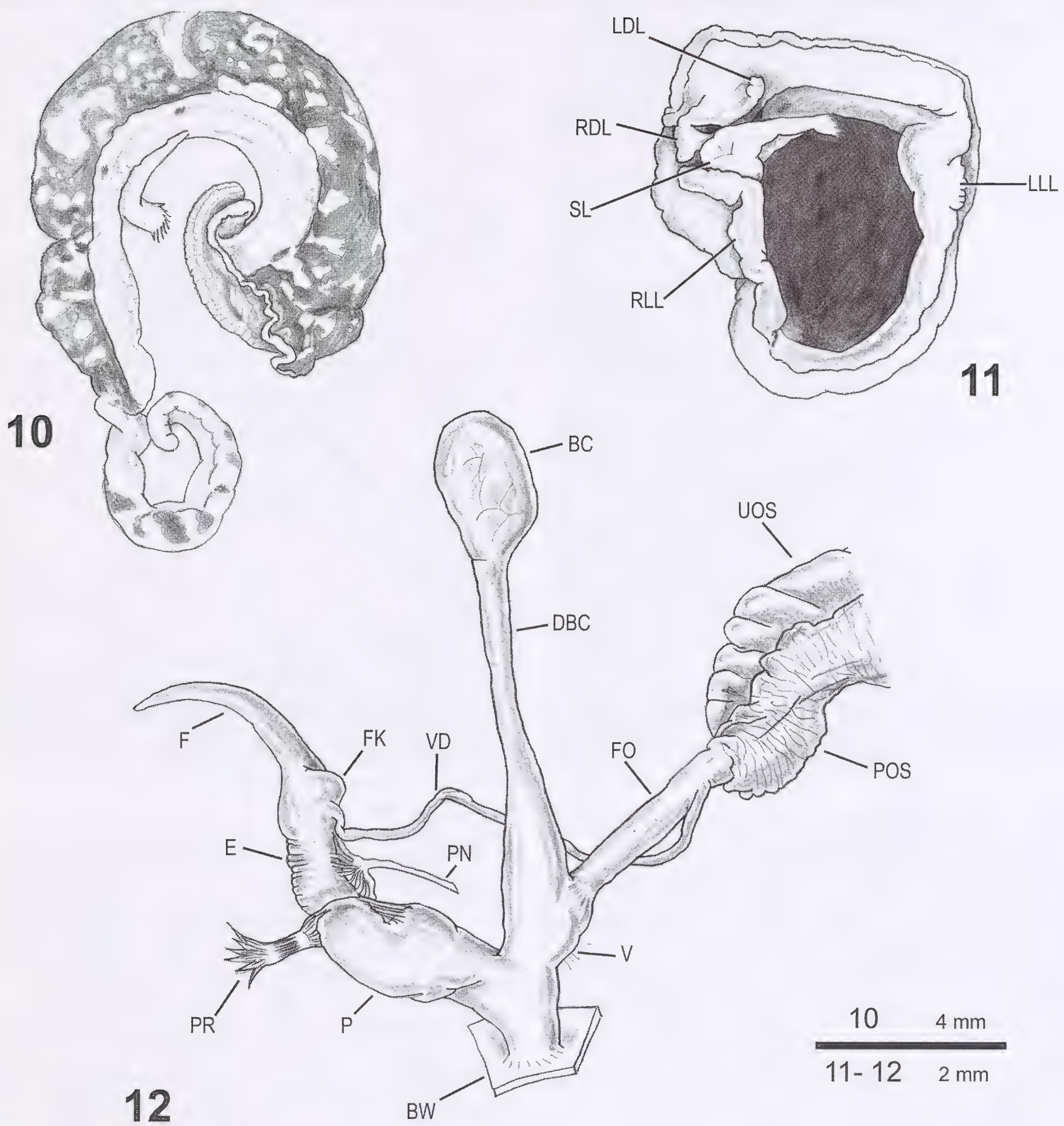
the distal genitalia). Female distal genitalia include free oviduct, bursa copulatrix [gametolytic gland] and its duct, and vagina. Vagina very short (0.5 - 0.6 mm; n: 2), without any trace of dart-sac complex and digitiform glands. Duct of bursa copulatrix rather long (3.2 - 3.7 mm; n: 2) and slender, its initial portion flared, its internal wall with series of slender pleats two of which swollen where free oviduct enters vagina. Bursa copulatrix oval, sac-like. Free oviduct long (1.2 - 1.6 mm; n: 2), initially slender, its distal part flared and cup-like.

Penial complex consisting of flagellum, epiphallus (from where flagellum ends, i.e. where vas deferens enters penial complex, to penial retractor muscle) and penis (from penial retractor to genital atrium). Flagellum moderately long (2.1 - 2.4 mm; n: 2), its base equal in calibre to epiphallus, showing evident knob level with where vas deferens enters penial complex, knob internally corresponding with structure bordering vas deferens opening into penial complex. Epiphallus rather short (1.0 - 1.6 mm; n: 2), variably wide, but always shorter than flagellum. Penis very short (1.4 mm; n: 2), almost completely enveloped by thin, subtransparent muscular sheath (sheath forcing penis to bend slightly upon itself and to appear slightly shorter than its actual length); internal penis without any kind of hygromiid penial papilla (either classical, traversed lengthwise by a duct continuous with lumen of epihallus/proximal penis, or tongue-like in the cases of *Ciliella* and *Canariella*, embracing epiphallus/proximal penis opening into distal penis with its base only); internal wall of penis with series of parallel pleats, larger inside distal part of penis (where penial wall appears to contain glandular tissue); one pleat swollen so as to give rise to variably shaped pseudopapilla, base of which comes to be situated at end of proximal penis; another pleat slightly swollen to form a pilaster-like structure, variable in shape, flanking pseudopapilla. Penial retractor muscle short and wide, inserted on penial sheath and ending on diaphragm walls. Genital atrium rather long and wide.

Radula consisting of many rows of 43 - 45 teeth according to the formula: 21 – 22 + C + 21 – 22. Central tooth with basal plate wide and upper vertices raised and pointed with strong mesocone flanked by two small ectocones. First lateral teeth with wide basal plate, inner vertex of which is missing, and strong mesocone and small ectocone, both pointed; inner side of mesocone without protuberance and gently concave. Moving toward radular margins, lateral teeth maintain shape, but become progressively smaller with more slender cusps and reduced basal plates. By 16th – 17th tooth of some rows, ectocone apex split into two points. Marginal teeth small, their mesocone slender and ectocone often split into 2 small points. Extreme marginal teeth very small, mesocone very reduced and ectocone apparently absent, possibly represented by row of very small low points.

Etymology named after Dr. Marco Bodon, a friend and a clever malacologist from Genoa (Italy).

Distribution *Schileykiella bodoni* n. sp. is endemic to Marettimo island. A shell, apparently indistinguishable (shell hairs similarly short) from those of *S. bodoni*, was allegedly collected at Gharb, Gozo Island (Maltese Islands) by H. Walden in 1970 (see Giusti *et al.*, 1995, as *S. parlatoris*). Although repeatedly sought by two Maltese colleagues (Prof. P.J. Schembri and Dr. M. Thake), no other *Schileikyella* specimen has ever been found on Gozo. This prevents us from confirming the presence of the genus in the Maltese Islands and from ascertaining the identity of the Maltese specimen.



Figs 10-12 Body (Fig. 10), mantle collar (Fig. 11) and distal genitalia (Fig. 12) of a specimen of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001.

DISCUSSION

Schileykiella bodoni n. sp. is very similar to *S. parlatoris* in shell size and shape. Both species have a contabulate shell quite different from the discoidal shell of *S. reinae*. The shell hairs of *S. bodoni* n. sp. are much shorter than those of *S. parlatoris* and more similar to those of *S. reinae* (Table 1).

This character attracted our attention as soon as the first shells of the new species came into our possession and prompted anatomical study to clarify the question. The genitalia turned out to be very similar to those of *S. parlatoris* (and very different from those of *S. reinae*; see Manganelli *et al.*, 1989, and Table 2) in general scheme and in certain details; other details were so different as to support, together with the shorter shell hairs, the status of distinct species for the Marettimo *Schileykiella*. These characters were the shorter vagina and epiphallus and the knob at base of flagellum (close to where vas deferens enters penial complex) opposite a peculiar internal structure. This structure coincides with the final part of a pleat inside the flagellum (extending from flagellum tip to vas deferens opening). Its function is obscure, but it may serve to surround and protect the vas deferens opening into the penial complex.

TABLE 1
Maximum hair length in the shells of *Schileykiella* species.

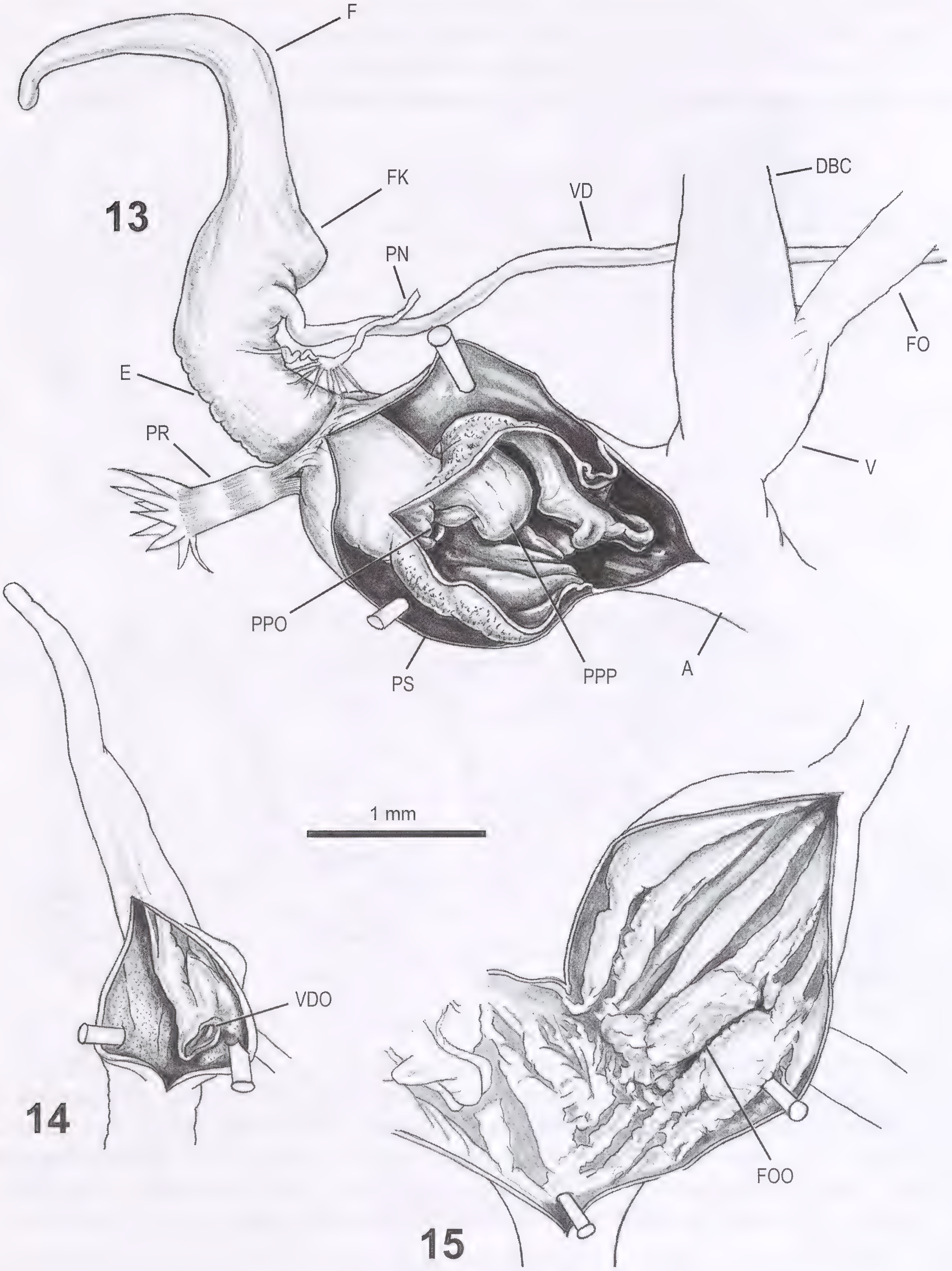
Schileykiella bodoni	*Schileykiella parlatoris*	*Schileykiella reinae*
Marettimo I., Pizzo Falcone, S. Cianfanelli & E.Talenti leg. 5.6.1997 (MZUF 20933)	Monte Cuccio, Reina leg. 10.1877 (Paulucci coll., MZUF 4710).	Timpone, S. Cianfanelli & E. Talenti leg. 30.4.1994 (MZUF 13267).
0.59 ± 0.06	1.60 ± 0.16	0.75 ± 0.03
(0.5 – 0.7)	(1.4 – 1.9)	(0.7 – 0.8)
n: 8	n: 8	n: 9

TABLE 2
Diagnostic characters of the three *Schileykiella* species.

	Schileykiella bodoni	*Schileykiella parlatoris*	*Schileykiella reinae*
Shell shape	contabulate	contabulate	discoidal
Hairs	short	long	medium
Duct of bursa copulatrix	short	short	very long
Vagina	very short	short	very short
Epiphallus	short	long	short
Flagellum	short	short	very long
Knob at base of flagellum	present	absent	absent
Internal structure bordering vas deferens opening into penis	present	absent	absent

All the specimens of *S. parlatoris* examined so far (Figs 19-26; Manganelli *et al.*, 1989: Figs 1-2), apart from the longer vagina and epiphallus, lack an externally visible knob at base of their flagellum and the corresponding internal structure. There is a pleat, similar to that seen in *S. bodoni*, which extends from flagellum tip to vas deferens opening (in one case this pleat had a very thin rolled crest along its entire length; Fig. 24), but the vas deferens opening is always freely visible, revealing sides with very small pleats (Figs 21-22, 24).

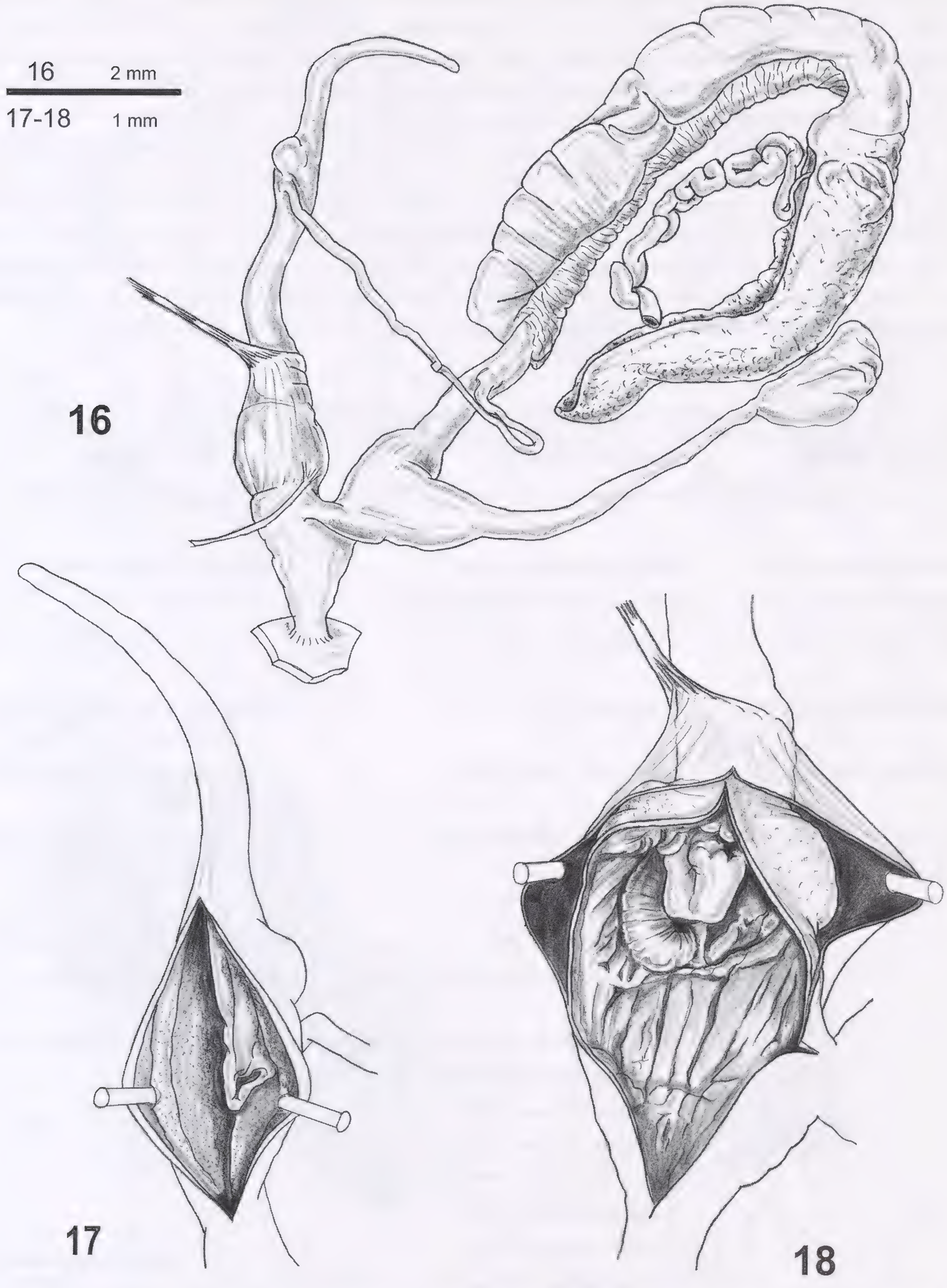
The two adult specimens of *S. bodoni* examined anatomically showed penis with an internal pseudopapilla matching to that described by Manganelli *et al.* (1989, Fig. 2 A-B) in one of the two dissected specimens of *S. parlatoris* from Monte Cuccio near Palermo (the other specimen from the same locality had a small knob; Manganelli *et al.*, 1989, Fig. 2 E). On the contrary both specimens of *S. parlatoris* examined on the present occasion, revealed penis without pseudopapilla (some of the pleats on the internal surface of penis were sligthly swollen close to epiphallus opening as to produce a sort of small knob). This fact and the different shape of the corresponding structures found in *S. bodoni* and in one specimen of *S. parlatoris* suggest that the pseudopapilla (and possibly the penial knob) is an ephemeral structure derived from occasional swelling of the basal



Figs 13-15 Internal structure of penis (Fig. 13), flagellum (Fig. 14), atrium, vagina and initial portion of bursa copulatrix duct (Fig. 15) of a specimen of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001.

portion of one of the penial pleats. Only study of more material can verify or disprove this hypothesis.

The present anatomical study of more material of *S. parlatoris* revealed certain characters (not described by Manganelli *et al.*, 1989) shared with *S. bodoni*: walls of distal penis probably containing glandular tissue (1); distal part of free oviduct flared and cup-like (2); penial retractor short and robust, apparently continuous with muscular penial



Figs 16-18 Genitalia (Fig. 16) and internal structure of epiphallus, flagellum (Fig. 17) and penis (Fig. 18) of a specimen of *Schileykiella bodoni* n. sp. from Island of Marettimo, Pizzo Falcone, 580 m, 33STC4107, S. Cianfanelli leg. 10.11.2001.

sheath (3); flagellum with internal pleat running from tip to opening of vas deferens into penial complex (4); left lateral lobe of mantle collar small (5).

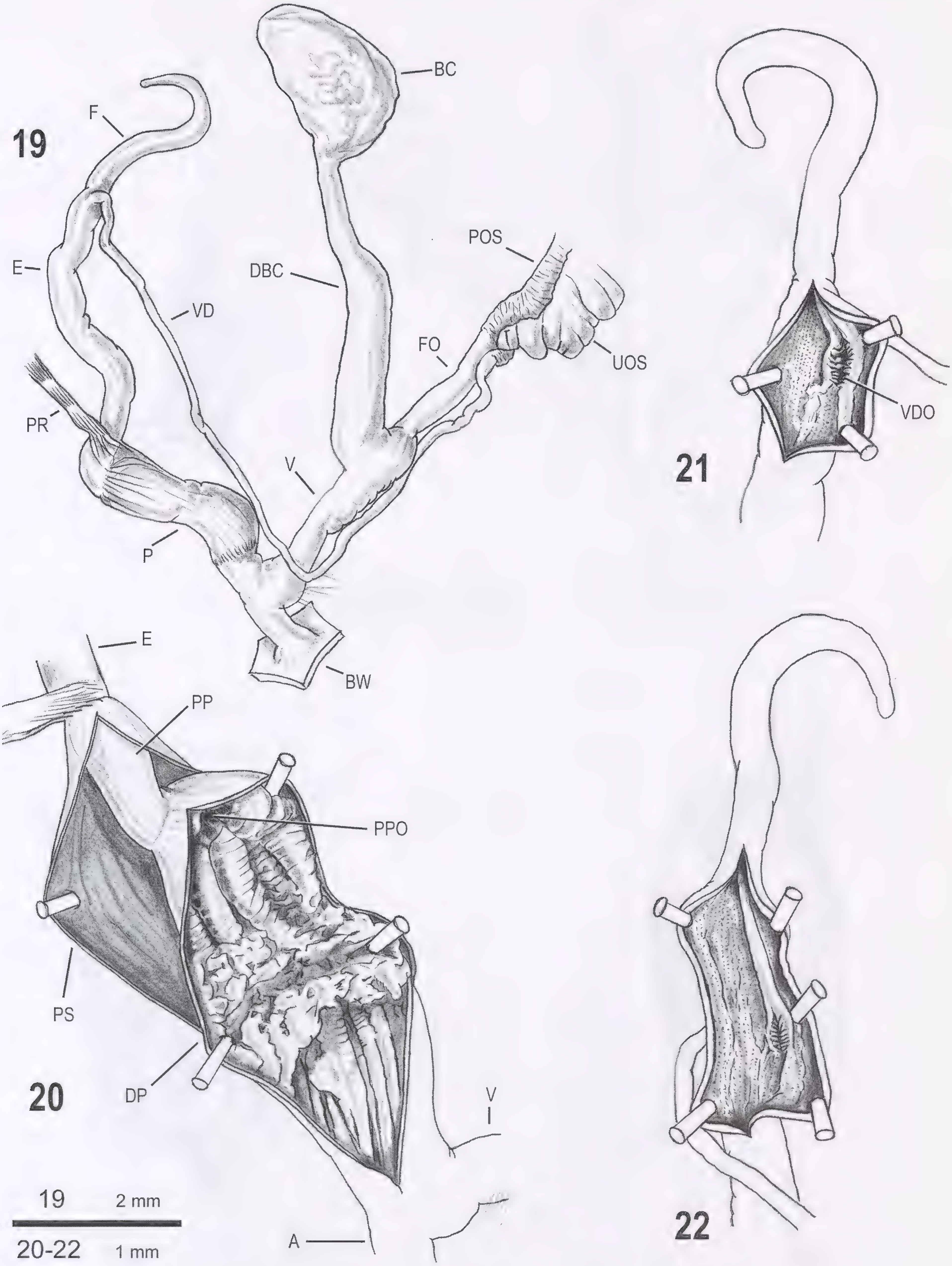
With regard to the relationships of *Schileykiella*, very little can be added to what we wrote when the genus was described (Manganelli *et al.*, 1989). Some authors recently proposed that it belongs to the same suprageneric group as *Ciliella*, i.e. the so-called cilielline hygromiids (Schileyko, 1991; Nordsieck, 1993; Bank *et al.*, 2001), but this remains a simple hypothesis. Indeed, apart from the very different composition of the lists of taxa included in the ciliellinae hygromiids by the authors (Table 3), we failed to find even one derived character supporting their monophyly (Table 4).

As Prieto *et al.* (1993) noticed, no genus included in the cilielline hygromiids has a periostracum with microsculpture similar to that of *Ciliella* (nail-like scales and spiral crests); one genus (*Cyrnotheba*) with similar periostracal microscultpture exists, but it has never been considered close to *Ciliella* and related genera. Some hygromiid genera have nail-like scales, but no spiral crests (*Hygromia*, *Riedelia*, *Cryptosaccus* and *Monachoides*); some have spiral crests, but hairs instead of nail-like scales (*Schileykiella*, *Ciliellopsis*, *Montserratina*, *Canariella*, *Plentuisa* and one species of *Xerotricha*, *X. apicina*).

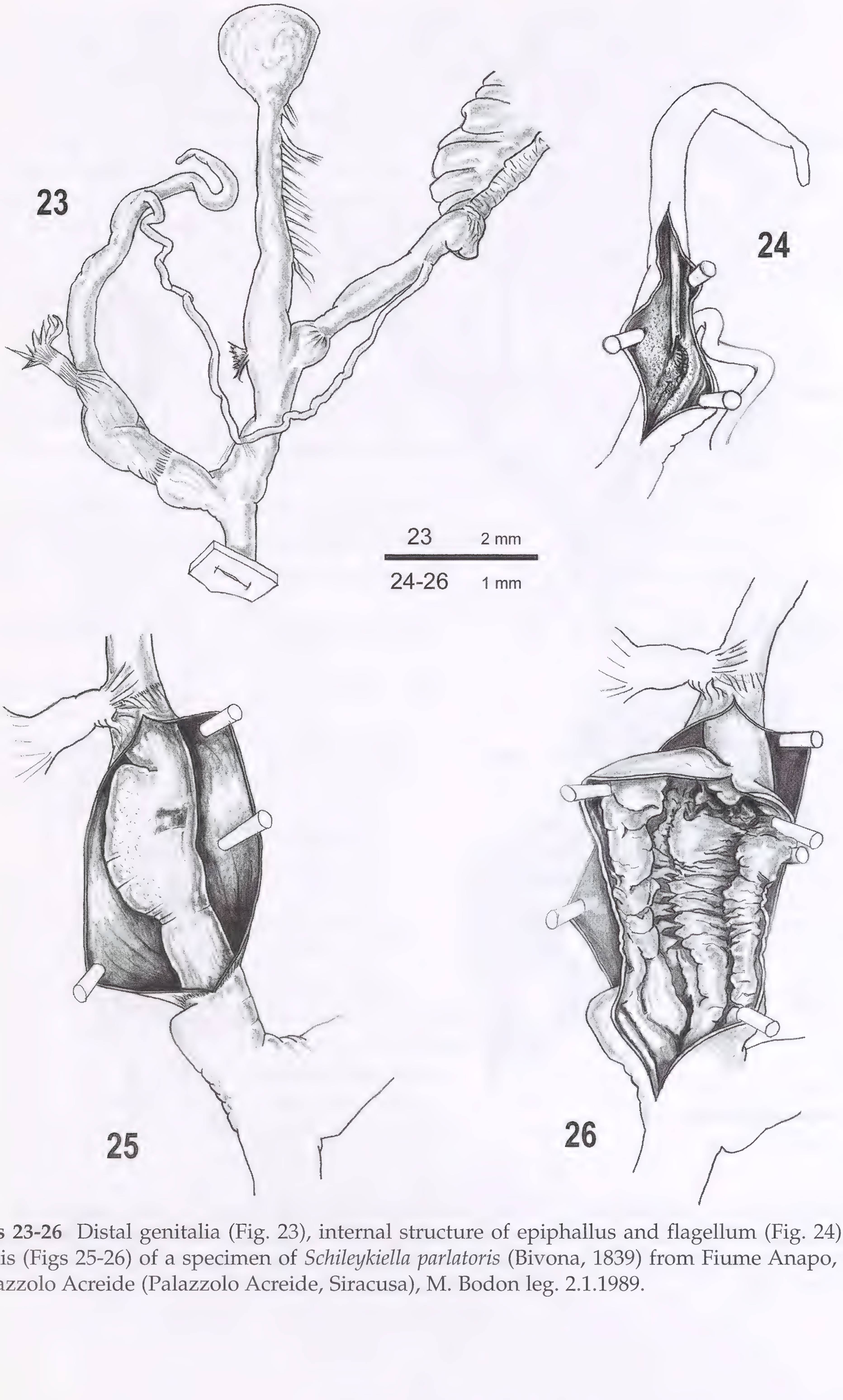
TABLE 3

Cilielline hygromiids according different authors.

Schileyko (1991)	**Nordsieck (1993)**	**Bank *et al.* (2001)**
Fam. Ciliellidae Schileyko, 1970	**Fam. Hygromiidae, Tryon, 1866**	**Fam. Hygromiidae, Tryon, 1866**
Ciliellinae Schileyko, 1970	**Ciliellinae Schileyko, 1970**	**Ciliellinae Schileyko, 1970**
Canariellini Schileyko, 1991	**Trissexodontini Nordsieck, 1987**	*Ciliella* Mousson, 1872
Canariella Hesse, 1918	*Mastigophallus* Hesse, 1918	*Montserratina* Ortiz de Zarate López, 1946
Ciliellini Schileyko, 1970	*Oestophorella* Pfeffer, 1929	*Schileykiella* Manganelli, Sparacio & Giusti 1989
Ciliella Mousson, 1872	*Trissexodon* Pilsbry, 1895	*Tyrrheniellina* Giusti & Manganelli, 1992
Haplohelix Pilsbry, 1919	**Oestophorini Nordsieck, 1987**	*Ciliellopsis* Giusti & Manganelli, 1990
Schileykiella Manganelli, Sparacio & Giusti 1989	*Canariella* Hesse, 1918	*Canariella* Hesse, 1918
	Caracollina Beck, 1837	*Canariella (Canariella)* Hesse, 1918
	Gasulliella Gittenberger, 1980	*Canariella (Alvaradoa)* Ibáñez & Alonso, 1994
	Gasullia Ortiz de Zarate Rocandio & Ortiz de Zarate López, 1961	*Canariella (Simplicula)* Ponte-Lira & Alonso, 1997
	Oestophora Hesse, 1907	
	Suboestophora Ortiz de Zarate Rocandio & Ortiz de Zarate López, 1961	
	Ciliellini Schileyko, 1970	
	Ciliella Mousson, 1872	
	***Montserratina* – Gruppe**	
	Montserratina Ortiz de Zarate López, 1946	
	Schileykiella Manganelli, Sparacio & Giusti 1989	
	Tyrrheniellina Giusti & Manganelli, 1992	
	Ciliellopsis Giusti & Manganelli, 1990	



Figs 19-22 Distal genitalia (Fig. 19) and internal structure of penis (Fig. 20), epiphallus and flagellum (Figs 21-22) in specimens of *Schileykiella parlatoris* (Bivona, 1839) from Monte Cuccio (Palermo, Palermo), 33SUC4722, I. Sparacio leg. 28.5.1986 (Fig. 21) and I. Sparacio leg. 1.2.1986 (Figs 19-20, 22).



Figs 23-26 Distal genitalia (Fig. 23), internal structure of epiphallus and flagellum (Fig. 24) and penis (Figs 25-26) of a specimen of *Schileykiella parlatoris* (Bivona, 1839) from Fiume Anapo, near Palazzolo Acreide (Palazzolo Acreide, Siracusa), M. Bodon leg. 2.1.1989.

TABLE 4
Character distribution in the cilielline hygromiids (as conceived by Bank *et al.*, 2001)

	Canariella	*Ciliella*	*Ciliellopsis*	*Montserratina*	*Schileykiella*	*Tyrrheniellina*
Shell shape	discoidal/globular	discoidal	discoidal	discoidal	contabulate/discoidal	discoidal
Hairs	very short	absent	very short	short	short to very long	very short
Nail-like scales	absent	present	absent	absent	absent	absent
Spiral crests	raised and very close	raised and very close	raised and very close	raised and very close	raised and very close	absent
Spiral grooves	absent	absent	absent	absent	absent	present
Dart-sac complex	absent	absent	absent	absent	absent	absent
Digitiform glands	present	absent	absent	present	absent	absent
Duct of bursa copulatrix	short to long	very long	medium	long	short to very long	short
Vagina	short to medium	very short (absent)	very short (absent)	medium	short to very short	short
Free oviduct	as long as or shorter than vagina	much longer than vagina	much longer than vagina	shorter than vagina	as long as or longer than vagina	as long as vagina
Flagellum	very short to medium	short and cup-like	very short	short	medium to very long	short
Epiphallus	longer than penis	shorter than penis	much shorter than penis	longer than penis	as long as penis	as long as penis
Penial papilla	present (open on one side and tongue-like) / absent	present (open on one side and tongue-like)	present	present	absent	rudimentary (rim-like)
Penial sheath	present	present	present	present	present	present

TABLE 5

Systematic position and main references to taxa cited in discussion on the status of the Ciliellinae

taxon	systematic position	main references
Canariella Hesse, 1918	Ciliellidae, Ciliellinae, Canariellini (Schileyko, 1991) Hygromiidae, Ciliellinae, Oestophorini (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Groh *et al.* (1984), Ibañez *et al.* (1995), Ponte-Lira *et* al. (1996)
Ciliella Mousson, 1872	Ciliellidae, Ciliellinae, Ciliellini (Schileyko, 1991) Hygromiidae, Ciliellinae, Ciliellini (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Giusti & Manganelli (1990)
Ciliellopsis Giusti & Manganelli, 1990	Hygromiidae, Ciliellinae, Montserratina-Gruppe (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Giusti & Manganelli (1990)
Circassina Hesse, 1921	Hygromiidae, Hygromiinae, Hygromiini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Fruticocampylaea-Metafruticicola*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Metafruticicolinae (Bank *et al.*, 2001)	Schileyko (1978)
Cryptosaccus Prieto & Puente, 1994	Hygromiidae, Hygromiinae, tribus incerta (Bank *et al.*, 2001)	Prieto & Puente (1994)
Cyrnotheba Germain, 1929	Hygromiidae, Euomphaliinae, Euomphaliinii (Schileyko, 1991) Hygromiidae, Hygromiinae, *Hygromia-Cernuella*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae Hygromiini (Bank *et al.*, 2001)	Giusti & Manganelli (1987)
Drepanostoma Porro, 1836	Helicodontidae, Helicodontinae, Drepanostomini (Schileyko, 1991) Hygromiidae, Helicodontinae, Helicodontini (Nordsieck, 1993) Helicodontidae, Helicodontinae (Bank *et al.*, 2001)	Prieto et al. (1993), Manganelli & Giusti (2000)
Gasulliella Gittenberger, 1980	Helicodontidae, Oestophorinae (Schileyko, 1991) Helicodontidae, Ciliellinae, Oestophorini (Nordsieck, 1993) Trissexodontidae (Bank *et al.*, 2001)	Puente *et al.* (1998)
Helicella Férussac, 1821	Hygromiidae, Trichiinae, Helicellini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Helicella-Candidula*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Helicellini (Bank *et al.*, 2001)	Giusti & Manganelli (1989b)
Helicella itala (Linnaeus, 1758)	see above	Giusti & Manganelli (1989b)

Helicodonta Férussac, 1821	Helicodontidae, Helicodontinae, Helicodontini (Schileyko, 1991) Hygromiidae, Helicodontinae, Helicodontini (Nordsieck, 1993) Helicodontidae, Helicodontinae (Bank *et al.*, 2001)	Prieto *et al.* (1993), Manganelli & Giusti (2000)
Hygromia Risso, 1826	Hygromiidae, Hygromiinae, Hygromiini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Hygromia-Cernuella*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Hygromiini (Bank *et al.*, 2001)	Giusti & Manganelli (1987)
Lindholmiola Hesse, 1931	Helicodontidae, Lindholmiolinae (Schileyko, 1991; Bank *et al.*, 2001) Hygromiidae, Helicodontinae, Lindholmiolinae (Nordsieck, 1993)	Prieto *et al.* (1993), Manganelli & Giusti (2000)
Metafruticicola von Ihering, 1892	Hygromiidae, Metafruticicolinae (Schileyko, 1991) Hygromiidae, Hygromiinae, *Fruticocampylaea-Metafruticola*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Metafruticicolinae (Bank *et al.*, 2001)	Schileyko (1972)
Mastigophallus Hesse, 1918	Helicodontidae, Trissexodontinae, Mastigophallini (Schileyko, 1991) Hygromiidae, Ciliellinae, Trissexodontini (Nordsieck, 1993) Trissexodontidae (Bank *et al.*, 2001)	Prieto *et al.* (1993)
Monachoides Gude & Woodward, 1921	Hygromiidae, Hygromiinae, Hygromiini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Perforatella-Leptaxis*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Leptaxini (Bank *et al.*, 2001)	Schileyko (1978)
Montserratina Ortiz de Zarate López, 1946	Hygromiidae, Ciliellinae, Montserratina-Gruppe (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Giusti & Manganelli (1989a)
Nienhuisiella Giusti & Manganelli, 1987	Hygromiidae, Hygromiinae, Hygromiini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Hygromia-Cernuella*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae Hygromiini (Bank *et al.*, 2001)	Giusti & Manganelli (1987)
Oestophora Hesse, 1907	Helicodontidae, Oestophorinae (Schileyko, 1991) Hygromiidae, Ciliellinae, Oestophorini (Nordsieck, 1993) Trissexodontidae (Bank *et al.*, 2001)	Prieto *et al.* (1993)
Oestophorella Pfeffer, 1929	Helicodontidae, Oestophorinae (Schileyko, 1991) Hygromiidae, Ciliellinae, Trissexodontini (Schileyko, 1991) Trissexodontidae (Bank *et al.*, 2001)	Prieto *et al.* (1993)
Plentuisa Puente & Prieto, 1992	Hygromiidae, ? Ponentininae (Bank *et al.*, 2001)	Puente & Prieto (1992)

Schileykiella Giusti, Manganelli & Sparacio, 1989	Ciliellidae, Ciliellinae, Ciliellini (Schileyko, 1991) Hygromiidae, Ciliellinae, Montserratina-Gruppe (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Giusti *et al.* (1989), this paper
Trissexodon Pilsbry, 1895	Helicodontidae, Trissexodontinae, Trissexodontini (Schileyko, 1991) Hygromiidae, Ciliellinae, Trissexodontini (Schileyko, 1991) Trissexodontidae (Bank *et al.*, 2001)	Prieto *et al.* (1993)
Tyrrheniellina Giusti & Manganelli, 1992	Hygromiidae, Ciliellinae, Montserratina-Gruppe (Nordsieck, 1993) Hygromiidae, Ciliellinae (Bank *et al.*, 2001)	Giusti & Manganelli (1989b)
Xerotricha Monterosato, 1892	Hygromiidae, Trichiinae, Helicellini (Schileyko, 1991) Hygromiidae, Hygromiinae, *Helicella-Candidula*-Gruppe (Nordsieck, 1993) Hygromiidae, Hygromiinae, Helicellini (Bank *et al.*, 2001)	Giusti & Manganelli (1989b)
Xerotricha apicina (Lamarck, 1822)	see above	Giusti & Manganelli (1989b)

With regard to genitalia, *Ciliella* lacks a dart-sac complex and digitiform glands, has a very short (absent?) vagina and a very long free oviduct. Many different hygromiid genera lack any residue of dart-sac complex and digitiform glands, some of them associated (*Schileykiella*, *Tyrrheniellina*, *Ciliellopsis*) or not (*Cyrnotheba*, *Gasulliella*, some *Circassina* species and *Metafruticicola*, etc.) with the cilielline hygromiids. The short vagina and long free oviduct of *Ciliella* is only shared by *Ciliellopsis*, *Schileykiella reinae* and certain species of *Canariella*. Other genera, associated (*Montserratina* and *Canariella*) or otherwise (*Nienhuisiella*, some *Circassina* species) with the cilielline hygromiids, lack dart-sac complex but have digitiform glands.

Ciliella has a penial sheath (continuous with the penial retractor muscle), a tongue-like penial papilla open on one side, a short epiphallus and a very short penial flagellum. A penial sheath is nevertheless present not only in the cilielline hygromiids (*Schileykiella*, *Tyrrheniellina*, *Ciliellopsis*, *Montserratina* and *Canariella*), but also in the trissexodontine hygromiids (*Trissexodon*, *Mastigophallus*, *Oestophora*, *Oestophorella*, etc.), the helicodontine hygromiids (*Helicodonta*, *Drepanostoma*, *Lindholmiola*, etc.) and some helicelline hygromiids (*Xerotricha apicina* and *Helicella itala*).

A penial papilla similar to that of *Ciliella* is only present in *Canariella*. Other cilielline hygromiids lack penial papilla (*Schileykiella*) or have a very rudimentary (*Tyrrheniellina*) or normal penial papilla (*Ciliellopsis* and *Montserratina*). Finally, a short epiphallus (equal to or shorter than half penis length) and very reduced flagellum are only present in *Ciliellopsis* and some *Canariella* species (for references to the taxa cited in the discussion, see Table 5). Probably, only a combined morphological and molecular analysis will further clarify the systematic relationships of these hygromiids.

In our opinion, different groups of hygromiids independently underwent progressive reduction of structures annexed to the vagina (dart-sac complex and digitiform glands). The many different conflicting combinations of morphological characters peculiar to single genera support this view, being clear evidence of how great a role, homoplasy played in the diversification of the hygromiids.

Schileykiella (*S. parlatoris* and *S. bodoni* in particular) is rather similar to *Tyrrheniellina* in the overall scheme of the genitalia, but differs by virtue of a true penial papilla (albeit very reduced) and different shell microsculpture (fine, close longitudinal grooves).

S. bodoni is a new entry among the paleoendemic species of Marettimo, which include the zonitine gastropod *Oxychilus denatale* (Pfeiffer, 1857), the diplopod *Afropachyiulus maritimus* (Strasser, 1969) and the coleopter *Typhloreicheia berninii* Magrini, Bastianini & Petrioli, 2003 (Strasser, 1969; Manganelli et. al., 1995; Magrini *et al.*, 2003). The island has been separate from mainland Sicily since the end of the Messinian (Late Miocene, 6.5 - 5.5 m.y. BP) and was not submerged during the marine transgression phase of the Pliocene. It is on the continental shelf which is about 150 m deep in that area. The drop of sea level (about 100 m), during the Quaternary glaciations, was not sufficient to re-establish a land connection with Sicily (Agnesi *et al.* 1993, 2000; Burgio, 1998).

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Appendix: list of localities

Schileykiella parlatoris (Bivona, 1839):

Localities not georeferenced – no data (12 sh, Priolo coll., MCSNM). Palermo (2 sh, MZUT; 11 sh, Priolo coll., MCSNM). Sicilia, 1874 (4 sh, Pecchioli coll., MZUF 20948; 2 sh, MZUT).
UB19 – Calatafimi (Calatafimini, Trapani), 33SUB19 (sh. 1, Priolo coll., MCSNM).
UB46 – Caltabellotta, 850 m asl (Caltabellotta, Agrigento), 33SUB46, M. Calcagno & S. Cianfanelli leg. 18.7.1988 (2 sh, SCC 2031/118).
UB59 – Bosco della Ficuzza, 900 m asl (Monreale, Palermo), 33SUB59, M. Calcagno & S. Cianfanelli leg. 18.8.1991 (1 sh, SCC 4003/664). Rocca Busambra (Monreale, Palermo), 33SUB59 (nn sh, FCMM).
UB89 – Caccamo, 500 m asl (Caccamo, Palermo), 33SUB8299, M. Calcagno & S. Cianfanelli leg, 18.8.1991 (7 sh, SCC 3914/662).
UC31 – Montelepre, 350 m asl (Montelepre, Palermo), 33SUC3917, M. Calcagno & S. Cianfanelli leg. 19.8.1991 (1 sh, SCC 3839/660).
UC42 – Monte Cuccio (Palermo, Palermo), 33SUC42 (4 sh, SMF 183567; 1 sh, De Betta coll., MCSNV), A. Bivona leg. (1 sh, SMF 183565), T. Monterosato leg. (3 sh Paulucci coll., MZUF 4712), D. Reina leg. 1870 (5 sh, Paulucci coll., MZUF 4712), L. Benoit leg. 1876 (2 sh, Paulucci coll., MZUF 4709), D. Reina leg. 10.1877 (7 sh, Paulucci coll., MZUF 4710). Monte Cuccio, Bellolampo (Palermo, Palermo), 33SUC4722, I. Sparacio leg. 26.11.1985 (1 sp, FGC), I. Sparacio leg. 1.2.1986, (2 sh, FGC), I. Sparacio leg. 28.5.1986, (6 sp. FGC).
VA79 – Calaforno (Giarratana, Ragusa), 33SVA7899 (3 sh, Paulucci coll., MZUF 4713).
VA87 – Cava d'Ispica, 340 m asl (Ispica, Ragusa), 33SVA87, M. Calcagno & S. Cianfanelli leg. 26.7.1988, (6 sh, SCC 2219/71).
VB09 – Madonie, Collesano, 500 m asl (Collesano, Palermo), 33SVB09, M. Calcagno & S. Cianfanelli 17.8.1991, (9 sh, SCC 7210/1383).
VB69 – SS 289, km 27 (San Fratello, Messina), 33SVB6799, F. Giusti & G. Manganelli leg. 10.10.1994, (1 sh, FGC).
VB82 – Militello (Militello in Val di Catania, Catania), 33SVB82 (5 sh, Paulucci coll., MZUF 4711).
VB90 – Fiume Anapo, near Palazzolo Acreide (Palazzolo Acreide, Siracusa), 33SVB9101, M. Bodon leg. 2.1.1989, (1 sp, MBC).
VC10 – Santuario di Gibilmanna, 800 m asl (Cefalù, Palermo), 33SVC10, S. Cianfanelli & E. Talenti leg. 27.4.1994, (1 sh, MZUF 13289).

Schileykiella reinae (Pfeiffer, 1857):

Localities not georeferenced – no data (13 sh, Monterosato coll., MCZR). Madonie (2 sh, Jetschin coll., SMF 100905). Maredolce (5 sh, Settepassi coll., MCZR). Palermo (2 sh, Settepassi coll., MCZR; 5 sh, Kobelt coll., SMF 183573). Sicilia (1 sh, De Betta coll., MCSNV), L. Benoit leg. 1874 (3 sh, Pecchioli coll., MZUF 20947).
UB19 – Calatafimi (Calatafimini, Trapani), 33SUB19 (4 sh, Blanc coll., MZUT), I. Sparacio leg. 5.12.1984, (1sh, FGC).
UC02 – Semaforo (San Vito Lo Capo, Trapani), 33SUC0028, F. Giusti & G. Manganelli leg. 07.10.1994, (4 sh, FGC). Timpone, 3 m asl (San Vito Lo Capo, Trapani), 33SUC0123, S. Cianfanelli & E. Talenti leg. 30.4.1994 (2 sh, SCC 5095/904; 89 sh, 2 sp, MZUF 13267).
UC10 – Monte Inici (Castellamare del Golfo, Trapani), 33SUC10 (16 sh, Monterosato coll., MCZR; 6 sh, Krüper coll. SMF 100904). Monte Inici, 1000-1004 m asl (Castellammare Del Golfo, Trapani), 33SUC1208, M. Calcagno & S. Cianfanelli leg. 30.8.1991 (33 sh, SCC 5647/967), S. Cianfanelli & E. Talenti leg. 27.4.1994 (1 sh, MZUF 10592). Monte Inici, Pizzo Brando (Castellamare del Golfo,

Trapani), 33SUC1208, F. Giusti & G. Manganelli leg. 12.9.1984 (4 sh, 1 sp , FGC), I. Sparacio leg. 12.3.1985 (8 sh, FGC), P. Fanciulli, E. Malatesta & G. Manganelli leg. 3.4.1985 (5 sh, FGC), I. Sparacio leg. 4.11.1985 (1 sp, FGC), I. Sparacio leg. 10.1.1987 (2 sp, FGC). Pizzo Stagnone (Castellamare del Golfo, Trapani), 33SUC1309, I. Sparacio leg. 12.12.1984, (6 sh, FGC).

UC11 – Castellamare del Golfo (Castellamare del Golfo, Trapani), 33SUC11 (3 sh, Monterosato coll., MCZR). Madonna della Scala (Castellamare del Golfo, Trapani), 33SUC1311, I. Sparacio leg. 1.1986, (nn sh FGC).

UC42 – Castelluccio presso Carini (Carini, Palermo), 33SUC42 (3 sh, MCZR). Monte Cuccio (Palermo, Palermo), 33SUC42, T. Monterosato leg. 1870, (2 sh, Paulucci coll., MZUF 20946), L. Benoit leg. 1877 (1 sh, Paulucci coll., MZUF 20945).

THE OPISTHOBRANCH MOLLUSCS DESCRIBED BY THE REVEREND ROBERT BOOG WATSON FROM THE MADEIRA ARCHIPELAGO (NORTHEAST ATLANTIC, PORTUGAL)*

MANUEL ANTÓNIO E. MALAQUIAS[1]

Abstract *Watson described nine species of shelled opisthobranch molluscs from the Madeira Archipelago in 1897. Type material for six of these species,* Diaphana flava, Pyrunculus spretus, Melanochlamys maderensis, Philine complanata, Philine trachyostraca *and* Berthella dautzenbergi *has been located in the collections of The Natural History Museum, London and the National Museum of Wales. This material is redescribed here and lectotypes are designated for five of the species. Non-type specimens of another of Watson's species,* Philine desmotis, *were also found. All of these seven species are here illustrated by scanning electron microscopy for the first time.*

INTRODUCTION

The Reverend Robert Boog Watson was a minister at the Scottish Church in Madeira from 1864 until 1874. In the course of his stay he dedicated part of his time to the study of the rich terrestrial and marine molluscan fauna of the archipelago. He collected most of the specimens himself. In addition he made contacts with fishermen, who dredged off Madeira using devices that he provided. He also obtained specimens from the islands of Porto Santo and Selvagens through both fishermen and friends who visited these islands.

The marine shells collected by the Reverend Richard Thomas Lowe, who had died after living on Madeira for more than fifty years and had produced a brilliant work on the natural history of the archipelago, also came into Watson's possession (Watson, 1891).

The study of all this material resulted in significant contributions by Watson to the knowledge of the molluscs of the Madeira Archipelago (see Smith & Tomlin, 1911, for a complete list of Watson's malacological contributions). In his last work (Watson, 1897), summarizing his knowledge of the marine molluscs, he listed 382 species of which 35 were new to science. A total of 34 species of opisthobranch molluscs, of which 26 constituted new records for Madeira and nine were new to science, were listed in this work.

The aim of this paper is to provide additional data on the opisthobranch species described by Watson from the Madeira Archipelago. This is a contribution to the continuing study of the opisthobranch fauna of the islands (e.g. Wirtz, 1999; Malaquias *et al.*, 2001, 2002). All the species are small and, with two exceptions, known only from their shells. Only one has been mentioned and figured since the first description, when Schiøtte (1998) transferred *Amphisphyra flava* to the genus *Diaphana*. Gosliner (1980) also transferred *Doridium maderense* to the genus *Melanochlamys*, but without studying or figuring the original material. A critical evaluation of the systematic placement and validity of the remaining species must await further monographic studies of the Atlantic fauna. Type material of five of Watson's species is present in The Natural History Museum, London, and of an additional species in the National Museum of Wales. Types of the remaining three taxa could not be located in these museums or elsewhere (National Museum of Natural History, Smithsonian Institution [according to

1 Department of Zoology, The Natural History Museum, London, SW7 5BD, United Kingdom (manm@nhm.ac.uk)

*Contribution of the Instituto Português de Malacologia

Robert Boog Watson
Novr. 1895

Figure 1 Photograph of the Reverend Robert Boog Watson (courtesy of The Natural History Museum, London).

Terry Gosliner pers. comm., there are no Watson types in museums in the United States]; Cambridge University Museum of Zoology; Natural History Collections University of Edinburgh). However, non-type material of one of these missing species has been found. Therefore it has been possible to redescribe and, for the first time, to figure by scanning electron microscopy seven of the nine shelled opisthobranchs described by Watson (1897).

MATERIAL AND METHODS

All material used in the study is housed in either The Natural History Museum, London (BMNH) or the National Museum of Wales, Cardiff (NMW). Shells were examined, uncoated, in a ISI ABT-55 Low Vacuum scanning electron microscope.

Selection of lectotypes and paralectotypes has been done only when specimens were accompanied by original labels with the word "type" handwritten.

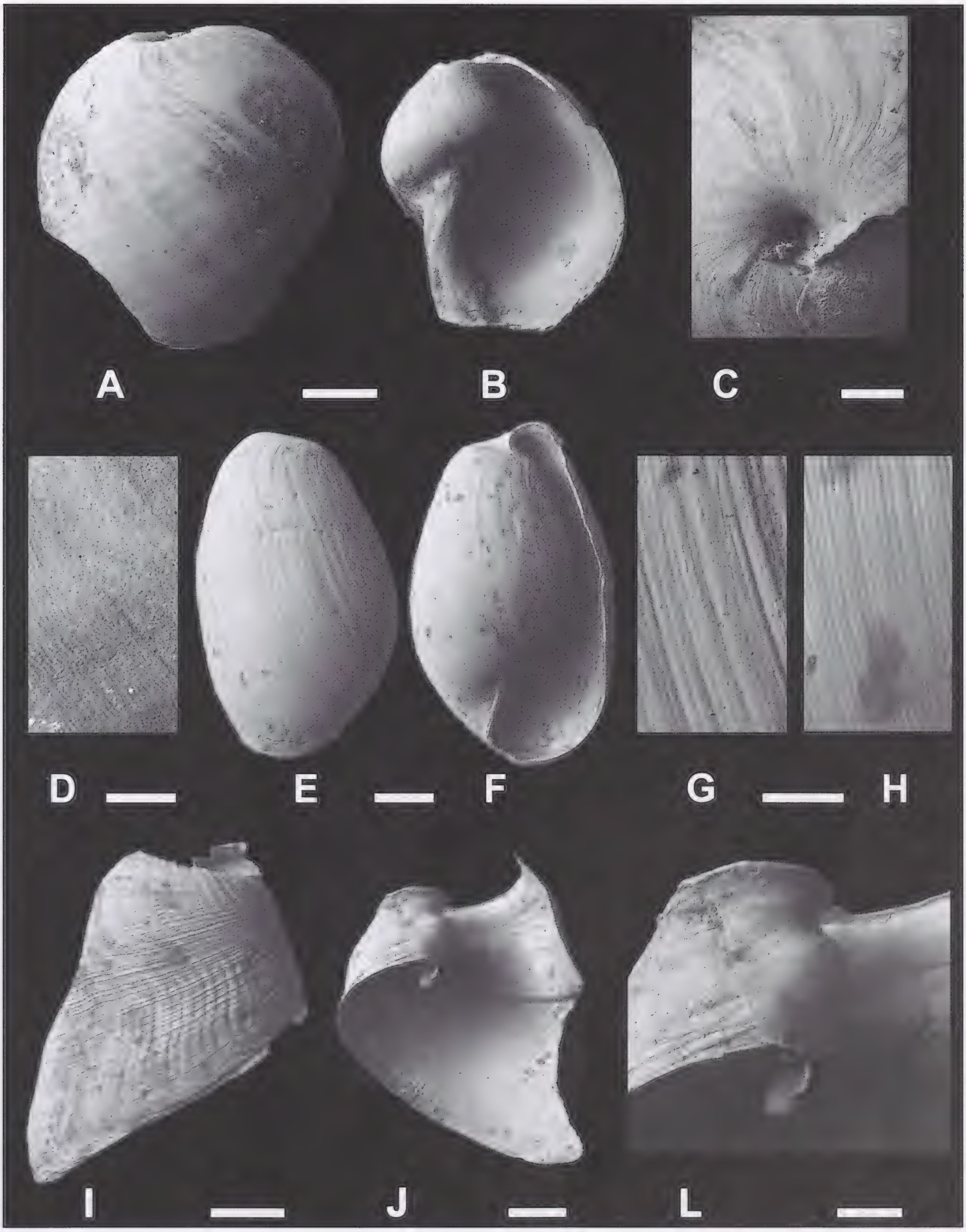

Figure 2 A-D *Diaphana flava* (Watson, 1897). A. Lectotype, BMNH 1911.7.17.29, adapertural view. B. BMNH 1996362, apertural view. C. Lectotype, BMNH 1911.7.17.29, detail of the spire. D. Lectotype BMNH 1911.7.17.29, detail of the adapertural part of the shell. E-H. *Pyrunculus spretus* (Watson, 1897). E. Lectotype, BMNH 1912.10.10.1, adapertural view. F. Lectotype, BMNH 1912.10.10.1, apertural view. G. Lectotype, BMNH 1912.10.10.1, detail of the adapertural part of the shell. H. Lectotype, BMNH 1912.10.10.1, detail of the apertural part of the shell. I-L. *Melanochlamys maderensis* (Watson, 1897). I. Lectotype, BMNH 1911.7.17.27, adapertural view. J. Paralectotype, BMNH 1911.7.17.28, apertural view. L. Paralectotype, BMNH 1911.7.17.28, detail of the embryonic shell. (Scale bars A-B, E-F, I-J = 500μm; C and L = 250μm; D, G-H = 100μm)

SYSTEMATIC DESCRIPTIONS

Diaphana flava (Watson, 1897)

Figure 2 A-D

Amphisphyra flava Watson, 1897: 234, pl. 19, fig. 2 ("From Funchal Bay along the S. coast eastward to Punta São Lourenço down to 50 fms.; Rare. Mr. Johnson got one specimen; I several, but chiefly young").
Diaphana flava—Schiøtte, 1998: 126, fig. 24F-H.

Type material Lectotype, designated by Schiøtte (1998), Madeira Island, shell 2.26mm in length, J. R. le B. Tomlin Colln., (BMNH 1911.7.17.29).

Additional material examined 1 spec., Madeira, V. W. MacAndrew Colln, (BMNH 1996362). 11 specs (6 complete and 5 broken), Madeira, Melvill-Tomlin Colln, (NMW.1955.158.02422).

Description Shell 1.00 to 2.80 mm in length, globose, fragile, with large aperture extending above spire. Sculpture consists of growth lines and gentle axial undulations. Spire involute, sunk in a minute pore-like depression. Colour semi-translucent, light brown.

Remarks This species is known only by his shell. Schiotte (1998) included the generic name *Amphisphyra* in his list of synonyms of *Diaphana* and transferred the species *A. flava* to the genus *Diaphana* based in the morphology of the shell. Nevertheless he noted some uncertainty about the valid status of this species.

Pyrunculus spretus (Watson, 1897) n. comb.

Figure 2 E-H

Cylichna spreta Watson, 1897: 234, pl. 19, fig. 1 ("The few specimens of this species I got from about 30 to 40 fms. off Porto Santo; they are nearly all quite young shells.").

Type material Lectotype here selected, shell 3.05 mm in length, Porto Santo Island (BMNH 1912.10.10.1).

Additional material examined 1 spec., Madeira, V. W. MacAndrew Colln (BMNH 1996364).

Description Shells 1.90 and 3.05 mm in length, cylindrical, broadest just below mid-length. Sculpture consists of irregular axial lines that are thinner on ventral side of shell. Aperture narrow above; slightly longer than spire, which is flattened or a little sunken. Colour opaque white.

Remarks This species is here included in the genus *Pyrunculus*, based on the pear-shaped outline, which is the main characteristic of this genus (see Tringali and Oliverio, 2001).

Melanochlamys maderensis (Watson, 1897)

Figures 2 I-L, 3 A-B

Doridium maderense Watson, 1897: 238, pl. 19, figs 7, 7a, 7b ("Funchal, Punta de São Lourenço, Caniçal. From shallow water to 50 fms. The shells of this species I found not

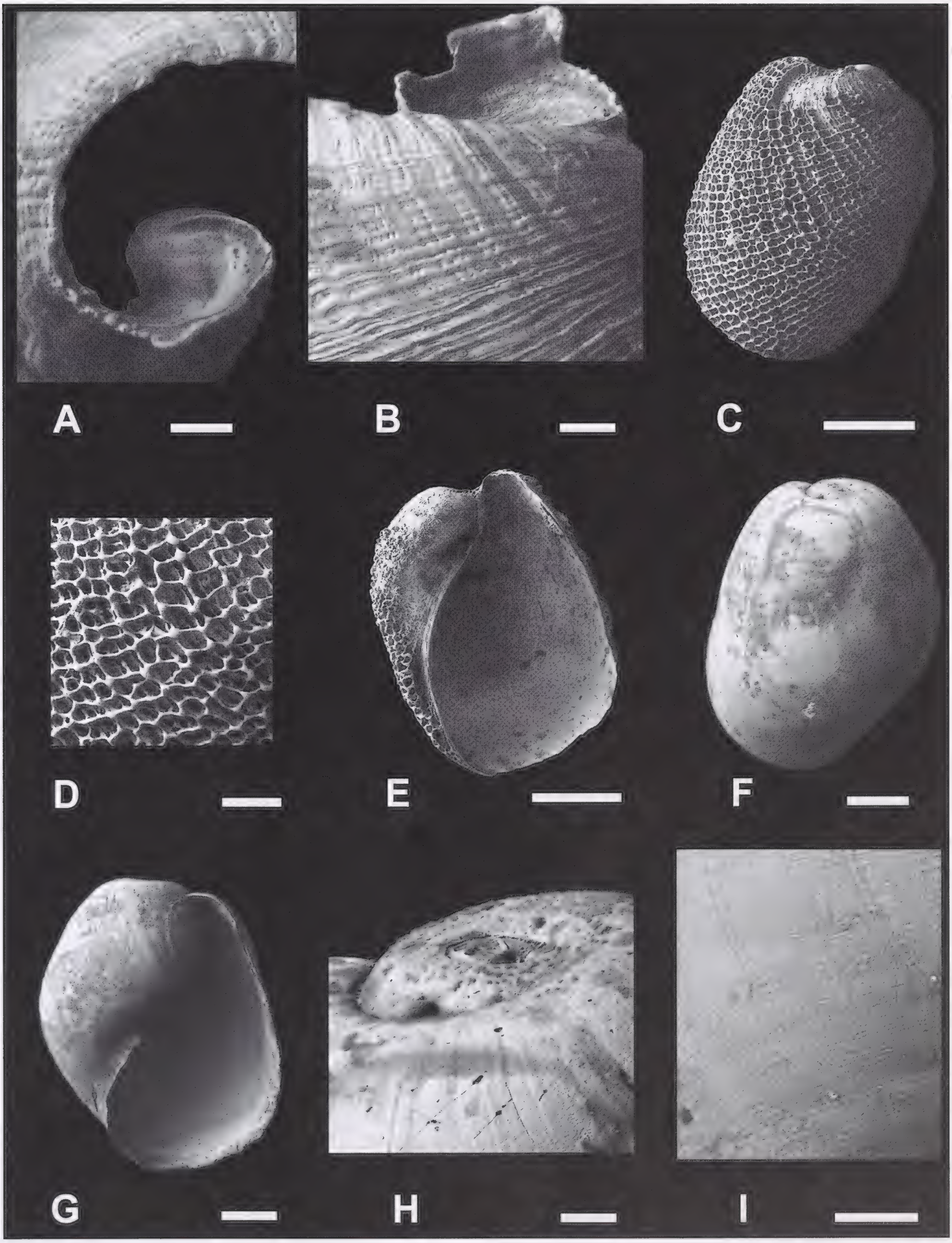

Figure 3 A-B. *Melanochlamys maderensis* (Watson, 1897). A. Lectotype, BMNH 1911.7.17.27, view of the top of the shell. B. Lectotype, BMNH 1911.7.17.27, detail of the spire. C-E. *Philine trachyostraca* Watson, 1897. C. Lectotype, NMW.1955.158.02421, adapertural view. D. Lectotype, NMW.1955.158.02421, detail of the adapertural sculpture. E. Lectotype, NMW.1955.158.02421, apertural view of the shell. F-I. *Philine complanata* Watson, 1897. F. Lectotype, BMNH 1911.7.17.13, adapertural view, G. Lectotype, BMNH 1911.7.17.13, apertural view. H. Lectotype, BMNH 1911.7.17.13, detail of the spire. I. BMNH 1911.10.26.6624, detail of the apertural part of the shell. (Scale bars A-B, D and I = 100µm; C, E-G = 500µm; H = 125µm).

unfrequently, but only one living animal presented itself.").
Melanochlamys maderensis—Gosliner, 1980: 337. Ortea & Moro, 1998: 103, pl. 2, fig. 1.

Type material Lectotype here selected, shell 2.35 mm in length, Madeira Island (BMNH 1911.7.17.27). Paralectotype, shell 2.74 mm in length, Madeira Island (BMNH 1911.7.17.28).

Additional material examined 12 specs, Madeira, Melvill-Tomlin Colln (NMW.1955.158.02417).

Description Shell 1.00 to 2.74 mm in length, completely calcified, fragile wing-shaped. Inner surface of shell smooth, outer surface with many spiral and longitudinal undulations. Colour opaque white.

Remarks This species is one of the only two which Watson (1897) described based on both shells and living specimens. Gosliner (1980) assigned this species to the genus *Melanochlamys* Cheeseman, 1881, based on the morphology of the caudal lobes and on the existence of a calcified shell. More recently, Ortea and Moro (1998) referred 10 specimens of the family Aglajidae (one from Cape Verde Islands and nine from Tenerife, Canary Islands) to *Melanochlamys maderensis*, based on their morphology and coloration.

Philine trachyostraca Watson, 1897

Figure 3 C-E

Philine trachyostraca Watson, 1897: 236, pl. 19, figs 4, 4a ("… I got only two specimens, one of them young - both from about 50fms. Funchal Bay.").

Type material Lectotype here selected, shell 1.77 mm in length, Madeira Island, Melvill-Tomlin Colln (NMW.1955.158.02421). Paralectotype, shell 3.00 mm in length (a shell fragment), Madeira Island, Melvill-Tomlin Colln (NMW.1955.158.02467).

Description Shells 1.77 mm and 3.00 mm in length. Shell fragile, convex dorsally, squared-oval in shape. Last whorl occupies entire shell length; aperture wide, posterior corner rounded and extending slightly beyond spire. Sculpture consists of a strongly raised network of spiral and coaxial elements with square depressions between. Colour white.

Philine complanata Watson, 1897

Figure 3 F-I

Philine complanata Watson, 1897: 235, pl. 19, fig. 3 ("Funchal Bay, 50 fms.").

Type material Lectotype here selected, shell 2.81 mm in length, Madeira Island, J. R. le B. Tomlin Colln (BMNH 1911.7.17.13).

Additional material examined 1 spec., Madeira, Norman Colln (BMNH 1911.10.26.6624). 8 specs, Madeira, Melvill-Tomlin Colln (NMW 1955.158.02418).

Description Shell 1.90 to 2.81 mm in length, globose, thin, smooth, with flattened spire. Last whorl occupies almost entire shell length. Sculpture of fine spiral striae and weak growth lines Aperture pear-shaped, narrowing posteriorly. Spire not projecting, almost flat. Colour opaque white, with a semi-translucent middle zone.

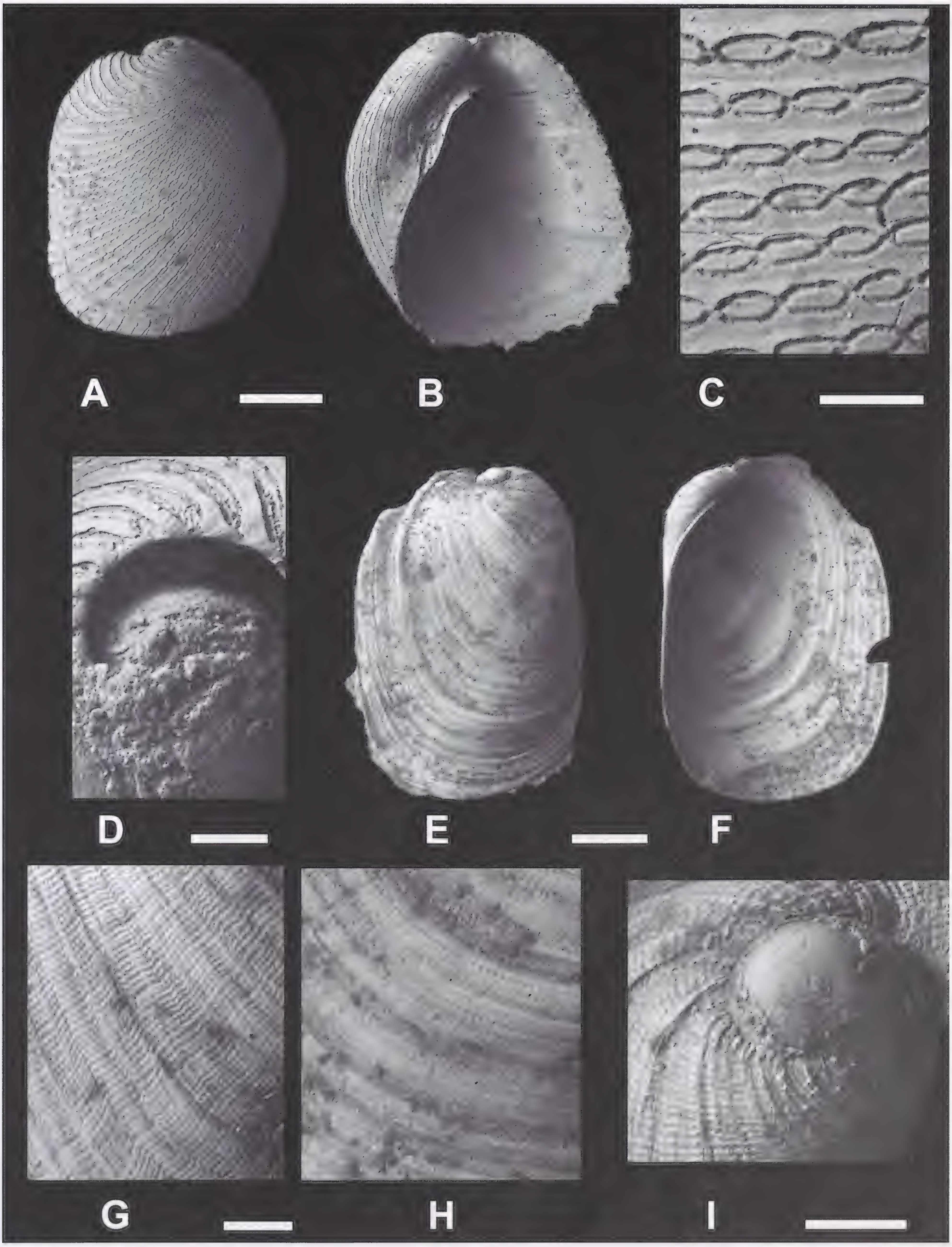

Figure 4 A-D. *Philine desmotis* Watson, 1897. A. BMNH 1911.10.26.6494-6497, adapertural view. B. BMNH 1911.10.26.6494-6497, apertural view. C. BMNH 1911.10.26.6494-6497, detail of the adapertural part of the shell. D. BMNH 1911.10.26.6494-6497, detail of the spire. E-I. *Berthella dautzenbergi* (Watson, 1897). E. Lectotype, BMNH 1911.7.17.25, adapertural view. F. Lectotype, BMNH 1911.7.17.25, apertural view. G. Lectotype, BMNH 1911.7.17.25, detail of the posterior adapertural part of the shell. H. Lectotype, BMNH 1911.7.17.25, detail of the anterior adapertural part of the shell. I. Lectotype, BMNH 1911.7.17.25, detail of the spire. (Scale bars A-B = 500 µm, C-D = 100µm; E-F = 1mm; G-I=250µm).

Philine desmotis Watson, 1897
Figure 4 A-D

Philine desmotis Watson, 1897: 236, pl. 19, figs 5, 5a ("Punta de São Lourenço, Santa Cruz; Porto Santo to 50 fms. Not rare.").

Material examined 2 specs, Madeira, Norman Colln (BMNH 1911.10.26.6494-6497). 55 specs, Madeira, Melvill-Tomlin Colln (NMW 1955.158.02419).

Description Shells 1.25 to 2.10 mm in length, fragile, obliquely squared-oval in shape. Aperture wide, extending slightly posterior to spire. Sculpture of spiral rows of incised oval rings, giving a chain-like appearance. Colour white, semi-translucent with a median translucent band.

Berthella dautzenbergi (Watson, 1897) n. comb.
Figure 4 E-I

Pleurobranchus dautzenbergi Watson, 1897: 239, Pl. 19, fig. 8 ("The species is not very common. ... two specimens at Magdalena. ...a few of mine came from near Funchal, but most ...came from...south shores towards Punta de São Lourenço.").

Type material Lectotype here selected, shell 4.37 mm in length, Madeira I.(BMNH 1911.7.17.25).

Additional material examined 1 spec., Madeira, J. R. le B. Tomlin Colln (BMNH 1911.7.17.26). 8 specs, Madeira, Melvill-Tomlin Colln (NMW 1955.158.02420).

Description Shell 2.50 to 4.80 mm in length, rectangular-oval, thin, flattened. Well marked sculpture of irregular growth lines and fine spiral striae, particularly conspicuous on posterior 2/3 of last whorl. Spire is a small, rounded knob. Colour opaque white.

Remarks Watson's description of this species was based on a few shells and on some notes by Rev. Lowe concerning one living specimen. In most cases features of the shell are not sufficient to separate pleurobranchid species and even members of different genera can have very similar shells. Despite this fact, it is possible to conclude that the present species does not belong to the genus *Pleurobranchus*. The shell morphology of the eastern Atlantic species of *Pleurobranchus (P. aerolatus, P. garciagomezi, P. membranaceus* and *P. testudinarius)* is different, with a more spatulate shape (Thompson, 1976; Cervera *et al.*, 1996). One possibility is to assign *P. dautzenbergi* to the genus *Berthellina*, of which the species *B. edwardsi* is common in Madeira. This species has a shell very similar to those studied by Watson. Nevertheless, the shell of *B. edwardsi* is usually smaller in size, not so rectangular, and the teloconch is usually inserted a little below the spire. In addition the colour of living specimens is always orange to red, never white as described in Lowe's notes on *P. dautzenbergi*. It is more appropriate to assign the species to the genus *Berthella*, of which two species, *B. plumula* and *B. stellata*, are known from Madeira, the latter being common (Watson, 1897, and Nobre, 1937, for *B. plumula* and personal observations for *B. stellata*). The protoconch, dimensions, ornamentation and auriculate shape of the shells studied by Watson are all within the range of the *Berthella* species known from Madeira. Supporting this proposed designation, the colour observed by Lowe for *P. dautzenbergi* ("animal was white", Watson, 1897: 240) is similar to that of the *Berthella* species known in Madeira (Cervera, 1988; Ocaña *et al.*, 2000; personal observations). On the basis of available information it cannot yet be determined whether *P. dautzenbergi* is a synonym of one of these *Berthella* species, or represents a distinct species.

Doridium laurentianum Watson, 1897

Doridium laurentianum Watson, 1897: pag. 237, not figured ("...only for minute shells ... in dredgings of 50fms. From Punta de São Lourenço...").

Remarks This species was originally described based on four dredged shells, of which two were lost (Watson, 1987: 237). The remaining two specimens could not be traced and the species was never illustrated by the author.

Pleurobranchus lowei Watson, 1897

Pleurobranchus lowei Watson, 1897: 240, pl. 19, fig. 9 ("...Mr. Lowe, ...one good specimen at Labra, near Punta de São Lourenço, to the east of which I got a quite unmistakable fragment.").

Remarks This species was described based on one shell and a fragment. Neither has been possible to trace.

ACKNOWLEDGEMENTS

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PHILIP PEARSALL CARPENTER'S "PASSION FOR SHELLS"

R. A. BAKER[1] & R.A. BAYLISS[2]

Abstract *Philip Carpenter was one of the most important early workers in American conchology, especially on the shells of the west coast of North America, and a leading conchologist in England in the mid-nineteenth century. Born in Bristol, he attended Manchester College, then at York, and served as a nonconformist minister at Stand, near Manchester, and at Warrington. He was interested in social and sanitary reforms. His most important work was on the shells collected by Frederick Reigen at Mazatlan, on the west coast of Mexico, from which he produced a catalogue for the British Museum and various reports for the British Association for the Advancement of Science. He emigrated to Canada in 1865 and died in Montreal while working on a monograph of chitons. Several museums in Europe and North America house Mazatlan shells and other Carpenter material.*

Key words *Carpenter, Mazatlan shells, taxonomy, geographical distribution.*

"A passion for shells" was the title of an exhibition on Carpenter and his shells held at the Redpath Museum at McGill University, Montreal, in 1994 (The Gazette, Montreal, January 22nd 1994). Carpenter, although born in England, emigrated to Canada in 1865 to live in Montreal and donated his remaining shell collection, now housed in the Redpath Museum, to McGill University. The present paper looks mainly at Carpenter's life in England prior to his emigration to Canada and considers the people, places, institutions and collections which shaped his career as a naturalist. Although his work on the conchology of North America is well documented and American malacologists have studied the shells associated with him, (Keen 1968, Palmer 1945, 1951, 1958), his earlier life in England is less well known and forms the basis of this paper.

Philip Carpenter was a remarkable man. Until 1861, much of his scientific, social and educational work was done in addition to his clerical duties as a nonconformist minister. Most of his important publications were between 1855 and 1865, "a measure of his productivity and abilities" (Coan, 1970). Parson naturalists were well known in Victorian Britain (Armstrong, 2000). Most of them worked their local areas and few became important figures abroad but Carpenter was one of these and his work in conchology made him an international pioneer. "Philip Carpenter ranks next to W. H. Dall (1845-1927) and Paul Bartsch (1871-1960) in the number of marine molluscan species described from the West Coast, San Diego to British Columbia…[and]…was one of the important figures in early American conchology" (Palmer, 1958).

EARLY LIFE AND FAMILY

Philip Pearsall Carpenter was born in Bristol on 4th November 1819, the youngest child of Lant Carpenter (1780-1840) a notable Unitarian minister. Mary Carpenter (1807-1877) the eldest child, became a social reformer and a brother, William Benjamin Carpenter (1813-1885), was a distinguished physiologist and zoologist (Gardiner, 2000).

EDUCATION AND EARLY EXPERIENCE

Philip was educated in his father's school, which included science lessons, then at Bristol

1 School of Biology, University of Leeds, Leeds LS29 6ES
2 18 Victoria Street, Stonehaven, Scotland, AB39 2LH.

Figure 1 Philip Pearsall Carpenter (frontispiece to R.L.Carpenter, 1880).

College and later in York and Manchester at the Dissenting Academy. Philip's early education was of "the highest type of devout and earnest Unitarianism then existing" (Gordon, 1880) but as a man he refused to be bound by any political or religious party. Although that early life moulded his character, he held views which embraced a wider church and found it impossible to remain satisfied with Unitarianism, " preferring practical religious regeneration…[than]…the mere demonstration of certain isolated points of theological doctrine" (Gordon,1880).

Like many Unitarians, Lant Carpenter, his father, had shown an interest in science, but it was the Bristol Institution (for the Advancement of Science, Literature and the Arts) which first fired Philip's enthusiasm for shells. Philip's father, brother William and sister Mary were all members. The Institution was founded in 1823 and had a museum, rich in molluscs and fossils; lectures on scientific topics were organised by the Bristol Philosophical and Literary Society which must have caught Philip's imagination. Family friends were to encourage him but two people in particular stand out. Samuel Stutchbury (1798-1859), the second curator of the Institution, from 1831 to 1850, gave him help and information, showing him important books held by the Institution. Stutchbury, who published a number of important scientific papers during his time at Bristol, was a modest and unassuming man, always willing to help and encourage others (Crane, 1983). Samuel Worsley (1808-1888), a local amateur geologist and Unitarian, was to play a vital role in determining the way Carpenter's interests developed. Worsley was partially sighted and Carpenter later wrote that, "It was to serve as eyes to guide his knowledge, that I commenced the study of shells" (Palmer, 1958). Worsley was on the members' list for the Bristol Institution in the late 1820s and was also, for a time, a member of the associated Philosophical and Literary Society. By the early 1830s, now in his early teenage years, Carpenter spent time in school holidays helping in the Bristol Museum. According to Palmer (1958), he had "at an early age developed a discriminating judgement of species determination". In 1833, he visited London for the first time to help in his late uncle's manufacturing optician's business and learned how to prepare microscope slides, but returned home when his strong desire to become a minister was made known. While in London he met John Edward Gray (1800-1875) who was to be an inspiring early influence. Gray, who from 1824 to 1874 was at the British Museum, first as an assistant then from 1840 as Keeper of Zoology, saw Carpenter's "remarkable aptitude" (Anon, 1877) for shell taxonomy and later persuaded him to deposit the first and best set of Mazatlan shells at the museum. As a consequence of this, Carpenter was asked to write the catalogue of that collection (Carpenter, 1857a,b).

In 1836 Carpenter attended the British Association meeting in Bristol where he met other scientists and in the same year, with his brother, William Benjamin, attended classes at the University of Edinburgh, showing a special interest in mathematical work (R. L. Carpenter, 1880). By this time Carpenter had a good working knowledge of shells and had arranged the conchological collection at the Bristol Institution.

CARPENTER'S LATER EDUCATION AND EARLY MINISTRY

In 1837 Carpenter began studies at Manchester College, which had moved to York, a training ground for Dissenting ministers, especially Unitarians. The college, which had earlier been in Manchester and returned there later, was never solely a theological college, but students training for the Unitarian ministry formed the majority and the number of lay students fell steadily from 1831. The college, in the traditions of the Warrington Academy before it, attempted to construct and teach a curriculum which was, "secular in content, liberal in tone, in touch with wider developments in the fields of science, political economy and so on" (Seed, 1982). The curriculum therefore was an enlightened one, involving the classics but also mathematics, mechanics, hydrostatics, pneumatics, optics, astronomy, experimental philosophy and natural history. A botany course started in 1824 (Seed, 1982) and there were objections from some that the curriculum was too broad . Among Carpenter's tutors were the Principal, Charles Wellbeloved, John Kenrick and the botanist William Hincks (Baker, 1999a). Thomas Hincks (1818-1899), William's son (Baker, 1999b), was one of the senior students when Philip began his studies and later was to be his predecessor at the Warrington Chapel. The college moved back to Manchester in 1840 when Philip was still a student but he found a lack of community there, was short of money and did not like the change. He wrote, "I am hurried on from one thing to another and have not a single hour to think" (Smith, 1986). He graduated BA (London) in 1841 with first class honours and immediately became minister at Stand, Lancashire (from 1841 to 1846) from where he continued to attend British Association meetings. These visits helped to rekindle "his ardour for natural history" (R. L. Carpenter, 1880).

In 1846 he was invited to Warrington as nonconformist minister at Cairo Street Chapel and decided to accept this appointment, after much deliberation and correspondence. His interests were widespread and one can understand the somewhat caustic comment of a biographer, reviewing the young minister's "endless philanthropic schemes, some wise and useful, others ill considered and unfruitful" (Moore, 1887). In a life-long concern for better health and continuing education, Carpenter used all the methods available, including the sensible use of a printing-press (which included the first issue of the Mazatlan Catalogue) and vivid teaching. In Warrington he carried out the major part of his ministry, accomplished most of his social work, established himself as an important local figure and became a respected figure in conchology.

Warrington had an important Dissenting Academy from 1757 to 1786 and the tutors there included Joseph Priestley (1733-1804) and Thomas Robert Malthus (1776-1834). Two years after Carpenter arrived, Warrington had a museum and library, the former established following a decision by the local Natural History Society to hand over their 2745 specimens to form the nucleus of the museum collections (Stephens, 1980). A new building provided for a library, museum and art gallery. Carpenter became a curator at the museum, spent much of his time there working on shells and published his first paper on molluscs (Carpenter, 1855), indicating the help he had received from Hugh Cuming (1791-1865). Cuming's collection played a large part in Carpenter's work on the Mazatlan shells and he had a lot of help from Cuming at various times. Carpenter was always on the lookout for material for the Warrington Museum and some 300 items are held there with some marine Mollusca from the Mazatlan collection (which Carpenter described but later split up). On his travels, he made large collections for the Warrington Museum, "consisting not only of shells, but of birds, reptiles, crustacea, dried plants etc. He had remembered its interests wherever he travelled" (R. L. Carpenter, 1880). Carpenter donated a collection of fossils and minerals as well as ethnological artifacts (information from Rolf Zeegers at the Warrington Museum).

Working in a provincial town like Warrington, which did not have a rich collection of

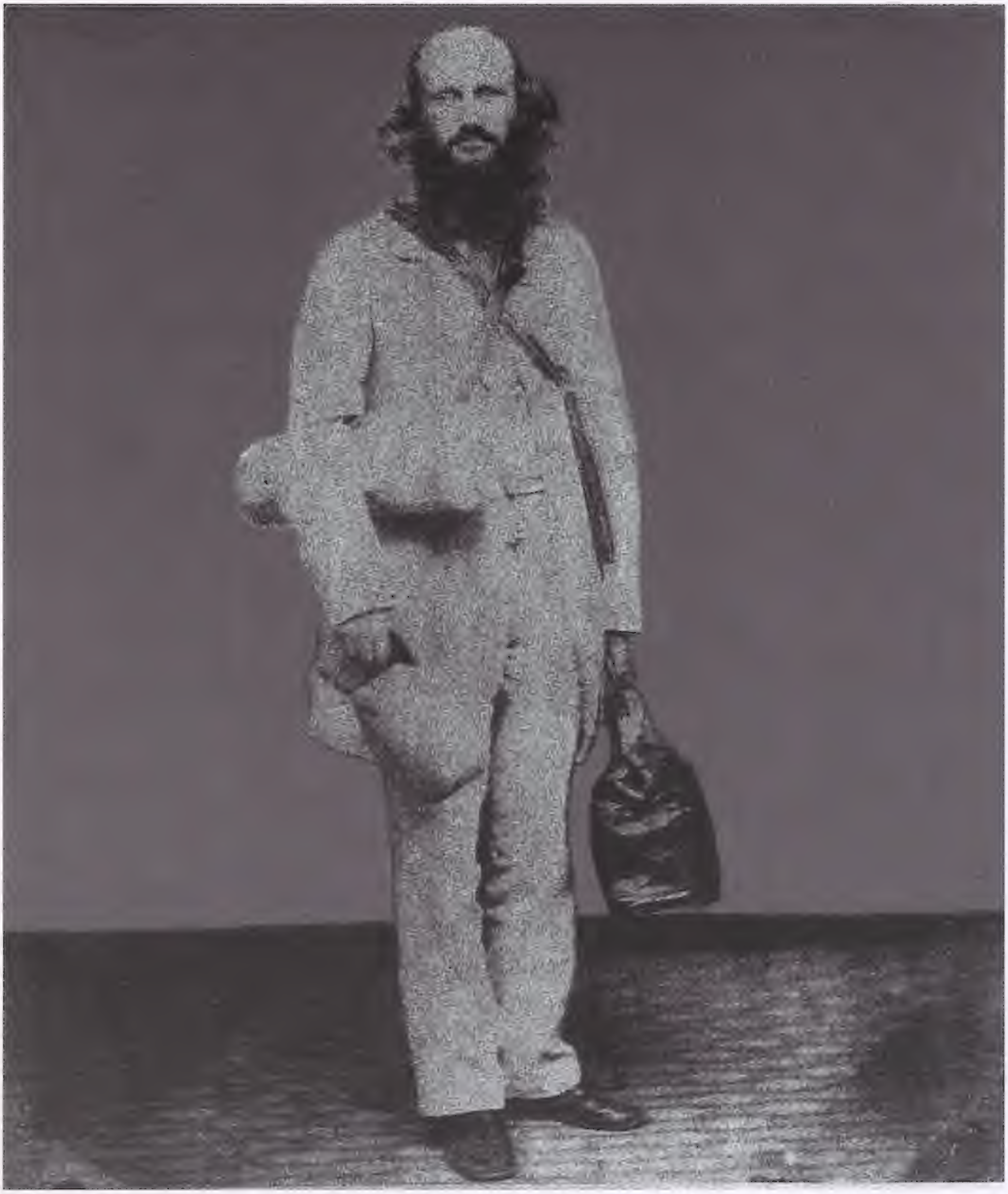

Figure 2 Carpenter dressed for field work, taken about 1860.

" a satchel slung over the right shoulder and under the left arm, containing my writing materials, etc.; a large botany box, strapped over the left shoulder; small carpet-bag containing change of linen and sundries, and a quire of blotting paper (for drying plants) between two mill boards; and an umbrella". (R.L.Carpenter, 1880 p.203).

Permission to use this photograph was obtained from the Museum of Comparative Zoology, Harvard University, © President and Fellows of Harvard College.

scientific books or collections, Carpenter was not well placed to carry out his scientific work and at the commencement had little knowledge of the literature. Indeed, it is not entirely clear how Carpenter amassed the historical and scientific information for such a detailed study. Many naturalists, from both sides of the Atlantic helped, and Carpenter was never afraid to ask. Typical was a letter he wrote to an unnamed person at the British Museum in 1856, "Mr Darwin refers me to Dana's Geology of the US Exploration Expedition for information of the Tertiary fossils of the West Coast of North America…of course I have no power of consulting it, as you have. Can you spare time to do so, and extract for me any lists that will bear on my branch with title and date of book" (Carpenter to British Museum, July 12th 1856).

CARPENTER AND THE MAZATLAN SHELLS

Moore (1887) refers to a chance event which occurred while Carpenter was walking down a street in Liverpool in the early 1850s. He saw some shells in a dealer's window, went in and found they were part of a vast collection which had been collected by Frederick Reigen. Little is known about Reigen, a Belgian, who "must surely be unrivalled - in any age - for the quantity of shells he amassed… with a determination amounting almost to mania" (Dance, 1986). Reigen's material was collected live, so much so that he was called before the police because of the stench from the decomposing molluscs on his premises (Palmer, 1958). Carpenter appears to have known about the collection and worked on some of these shells prior to 1855. The true story of when and how this occurred is not clear but there can be no doubt that the event gave Carpenter a renewed focus for an extraordinary and lasting burst of activity which transformed his life.

With financial help from his brother-in-law, Herbert Thomas, he bought part of the collection for £50 from George Hulse, a dealer in natural history in Dale Street in Liverpool. Hulse operated from both 146 and 160 Dale Street and is listed as a turtle dealer in Gore's directories of Liverpool in 1859 (information from Roger Hull, Liverpool Record Office). Reigen had collected the shells along the western coast of Mexico between 1848 and 1850 and the collection had arrived in England following Reigen's death. The Liverpool portion alone weighed 14 tons and each ton measured about "40 cubic feet" (Carpenter, 1857c); the rest had gone to Le Havre. Hulse had purchased the collection and almost at once disposed of many of the larger shells to a publican living near Manchester, in order to save room in his stores. R. D. Darbishire, an early helper, accompanied Carpenter to examine Hulse's "secret chamber" (Carpenter,1857c). Carpenter later wrote his own account of the episode. "Being desirous of making the permanent collection of the British Museum as complete as possible, and finding that the original stores were in danger of being dispersed, and so rendered useless to science, I obtained possession of the remainder of the vast collection, and subjected it to a renewed and more rigid scrutiny" (Carpenter, 1857c). Carpenter had a unique method of mounting shells. Many of his specimens were mounted on glass tablets and labels were written on the glass using white ink.

Carpenter produced three major works, two for the British Association (1857c, 1864) and a catalogue for the British Museum (1857a,b). In addition to these, there was a brief report read before the Liverpool meeting of the British Association in 1854 (published 1855). It shows that Carpenter knew about this collection prior to 1855 and is thought to have received help from Edward Forbes (1815-1854). Forbes had recommended that the shells be transferred to the British Museum. Carpenter was requested by the British Association for the Advancement of Science to produce the first "Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America" for the Cheltenham meeting in 1856. The object of this report was to condense and

Philip P. Carpenter
Feb 15th, 1861.

Figure 3 Signature of Philip Pearsall Carpenter (from Biology Curators' Group Newsletter 2 (9) 1981 p.426.

arrange existing material and knowledge. Carpenter began the report with a statement that "in consequence of an opportunity which an accident had thrown in his way" he had found himself "almost entirely destitute of technical knowledge" and "deprived by death of help promised", thought to be a reference to Edward Forbes. In 1864, in order to correct a number of errors and to add a great deal of fresh information, he produced a "Supplementary Report" on the same subject which was published in 1864, following the British Association meeting in 1863. In the 1857 report, he stated the physical conditions of the area, the sources of information in historical order, tabulated the geographical and zoological information and "drew inferences as the present state of our knowledge may warrant". He emphasised the errors which may occur in nomenclature, site names and collections and acknowledged the help of several well-known conchologists, including A. A. Gould (1805-1866), S. C. T. Hanley (1819-1900), W. Baird (1803-1872), S. P. Woodward (1821-1865) and L. A. Reeve (1814-1865). He was clearly aware of the importance of geographical distribution and was a pioneer in the field of molluscan biogeography. He said, "My principal object in the preparation of these works has been to make out and compare the writings of previous naturalists, so that it might be possible for succeeding students to begin where I left off, without being obliged to waste so large an amout of time as I have been compelled to do in analyzing the (often inaccurate) work of their predecessors" (Carpenter, 1872). Indeed, he was often highly critical of the work of others. Russell Carpenter wrote that "When I looked at it first, [Carpenter, 1857c] and saw page after page filled with names, I asked him how many members of the (British) Association he expected would study it. He hoped there would be half a dozen, but observed that the record would be valuable for future naturalists" (R. L. Carpenter, 1880).The reports were laying the foundations for future work. Palmer (1958) commented on these reports as a "wealth of concise information of Eastern Pacific conchological literature". William Henry Dall (1845-1927) refers to the importance of the 1857 and 1864 papers as "of utmost value to students of the Tertiary and recent molluscan fauna …they not only analysed the literature from the beginning but systematized the data contained in it in a masterly way and at the cost of great labour" (Dall, 1909).

The Catalogue of the Mazatlan shells in the British Museum (1857a,b) was the result of a major donation of shells to the British Museum. The shells, known as the first set, were presented by Carpenter on condition that he wrote the Catalogue. "I presented 8800 shells to the British Museum being the great Reigen collection…I was paid £50 for writing the Catalogue, which turned out to be an entire year's work" (Carpenter in litt. to Gunther August 11th 1875). There are two versions of this 552-page book, one published in Warrington and printed by Carpenter using the Oberlin press, a co-operative, with a preface by the author, the other published by the Trustees of the Museum, with a short preface by J. E. Gray. Gray emphasises how the work illustrates "the local fauna of a known station" at the mouth of the Gulf of California and exhibits the "amount of variation within a species by comparing large numbers of individuals". Unfortunately the shells were not illustrated in the Catalogue. The US National Museum possesses a complete set of drawings of the new species, made by Carpenter, and illustrations to the Catalogue have since been reproduced by Brann (1966). The "fact that he listed nearly a sixth as indeterminate and synonimized over a hundred existing names shows that he was not an indiscriminate splitter" (Galbraith and Dance, 1961). When the British Museum published a history of their collections in 1906 (Smith, 1906), reference was made to the Mazatlan shells which indicates that the collection was donated in 1857 and "692 species are enumerated or described…the total number of specimens amounts to 8800...and as a geographical series are of considerable importance". Keen (1968) describes it as a "pioneer work". The importance lies in the fact that it was an almost complete collection from a limited area and was examined in great detail and catalogued.

NORTH AMERICAN JOURNEY

Carpenter first visited North America in 1858, sailing from Liverpool on December 8th on "S.S. Kangaroo" (Palmer, 1951) in a steerage cabin and in tempestuous weather (R. L. Carpenter, 1880). He visited museums, gave lectures, examined specimens, arranged collections and met fellow scientists. His first task was to deliver boxes containing more than 6500 shells, the "first duplicate" set, to the New York State "Cabinet" of Natural History, at Albany. The material came as a gift but according to Palmer (1951) he was paid for arranging it. Later he visited leading conchologists and institutions in North America, including A. A. Gould, and at the Smithsonian Institution he met the Director, Joseph Henry (1797-1878). During his stay, the University of New York, through the Regents at Albany, awarded him their first Doctorate in Philosophy. This was further recognition of his growing international status.

CARPENTER'S OTHER WORK ON SHELLS AND COLLECTIONS

Although the Mazatlan collection and the eastern Pacific molluscan fauna dominated his life and work, he did much more. He published articles on nomenclature, fossil molluscs, and on several groups such as the Caecidae, Calyptraeidae, Pandoridae, Pyramidellidae, Trochidae and Vermetidae. When he died, he had been actively working on chitons, preparing a report to be published by the Smithsonian Institution. Palmer (1958) thought that this would have "exceeded the British Museum Catalogue (1857a,b) in size and importance" and Dall said it was "the most valuable scientific treatise on the subject in existence" (R. L. Carpenter, 1880), but it was never published. Carpenter also examined and deposited other collections in Europe and North America. In England for example, material relating to Carpenter and Mazatlan can be found at museums in Bolton, Scarborough and Warrington and at several others. In 1874 he was arranging the shells of the Boston Natural History Society (Carpenter, in litt, to J. E. Gray June 19th 1874). A year later he claimed to "have overhauled all the principal US collections, except Philadelphia" (Carpenter in litt. to O. A. L. Morch , May 24th 1875).

LAST YEARS IN ENGLAND

On the voyage back to England, Carpenter read Darwin's "Origin of Species" before attending the British Association meeting in Oxford in 1860 (R. L. Carpenter,1880) but "never really applied Darwin's ideas" (Coan, 1970). In the same year, and with his adopted son between them at the altar, he married Minna Meyer of Hamburg. However, he was unsettled and had set his heart on Canada. "My feeling is…that in the present prospect of American affairs, there is sure to be any amount of good work to be done, by speech, pen and life : with better interest (so to speak) for labour-capital, than is likely to be here…I have no mission, or call, or definite purpose ; but feel as though I wished to report at Montreal, and be ready for orders from the Shepherd" (R. L. Carpenter, 1880). By then even his sister Mary, who did not want to lose him, felt it was the right decision, but hoped he would "never enslave himself to shells again" (R. L. Carpenter, 1880). Harriet Martineau (1802-1876) a prolific author, controversial journalist and friend, was more outspoken and tried to dissuade him from emigrating, adding, "well you can come back if you don't like it" (Harriet Martineau in litt. to Carpenter, no date).

Following his resignation from the Warrington chapel in 1861, he spent the next four to five years at the museum in his "large, light, airy and orderly workroom. I rarely speak a word" (R. L. Carpenter, 1880). He had much to do, catching up on correspondence, examining shells, preparing to send back collections to America, writing reports and carrying out promised work for the Smithsonian Institution. He wrote, "I rise at six or before: go straight to the museum ; work incessantly, except when eating, till ten pm. This gives me nearly fifteen hours a day, close work. I think of nothing else (R. L. Carpenter, 1880) He was working so hard away from his ministry that his sister became worried about him. Mary wrote, "How sad … you should be exiled from human beings …Scientists' work is very valuable and beautiful ; but there are many who can do that : few the other. Do seek a location, where the precious gifts God has given you may be used for His children". (R. L. Carpenter, 1880). His family were not sorry to hear that in the summer of 1864, the room he used at the museum was required for a reference library and the Cairo Street Trustees asked him to vacate part of the house he rented from them for the storage of his shells. This curtailed his work but he was able to complete his next report and arrange for three typical series of Mazatlan shells to be sent to museums abroad.

NOTE ON EMIGRATION TO CANADA

He finally emigrated on October 26th 1865 and took up residence in Montreal, returning only once more to Warrington in 1874 to see old friends, members of his church and to do some conchological work. In Canada he taught, took up earlier interests in sanitary reform, continued his writings and developed a close friendship with John William Dawson (1820-1899) and with William Edmond Logan (1798-1875). People who visited him at his home were surprised to find that they had to watch him washing shells as he talked to them! He donated his remaining shells to McGill College (now McGill University). Carpenter claimed that this was the only collection in North America named in London from H. Cuming's material. Prior to this he wrote to Professor Dawson, Principal of McGill College, "I consider this collection to be far too valuable to be in the hands of a private person… I am willing to present it to your museum" (R. L. Carpenter, 1880). Carpenter saw "the necessity of type specimens, adequate repositories for them, and the exchange of materials named from types" (Coan, 1970). This collection is still in the possession of the University and held in the Redpath Museum, McGill University, Montreal. Carpenter's health declined and he contracted typhoid fever. He died in Montreal on May 24th 1877.

DISCUSSION AND CONCLUSION

Philip Pearsall Carpenter had the good fortune to belong to an enterprising and compassionate family. His education, from the first lessons in his father's school, included a scientific element, complemented by varied and interesting practical experience. His chosen vocation was the service of the church and social reform was part of this. In his brother's words, commenting on the 1836 British Association meeting at Bristol, "with all his love of natural history, the ministry was his heart's desire" (R. L. Carpenter, 1880).

It is our view that by the time Philip had attended lectures at Edinburgh University in 1836, he was a naturalist of sound education and with a better grounding than many other naturalists at the start of their careers. There were years to come when the scientific element in Carpenter's life lay dormant, although he was able to attend some of the British Association meetings, and it seems likely that he was able to carry on significant self education. His own self doubts were perhaps the expression of a naturalist out of practice, confronted by a formidable volume of exacting work and other pressing commitments. The circumstances of the Mazatlan collection and Carpenter's purchase are not clear. At the time shell collecting was a popular hobby as well as a serious scientific pursuit and dealers were in business. The date of his major purchase is incorrectly given in R. L. Carpenter's memoir (1880), for the first small Mazatlan paper was in the hands of the British Association in 1854. The precise reason for Carpenter's purchase can only be guesswork, and what might have been a matter of impulse and opportunism was fortunately the right one for conchology.

Carpenter, as a result of arduous labour, dedication, generous help and personal sacrifice achieved much in a relatively short period of time. His early scientific background was an important factor in his success. Without mentioning Carpenter, Allen (1978) gives examples of "astonishing displays of intellectual stamina" in the work of naturalists and Carpenter's work is a clear example. The often quoted remark of Louis Pasteur could be remembered in this context that "chance favours only the prepared mind" (Beveridge, 1979).

The publications of Philip Pearsall Carpenter reflect many of his interests but a difficulty remains. There does not appear to be a complete bibliography of his work. Coan (1969) published a list of "biological writings" with 62 titles, including works from Carpenter's period in North America. Much of his work was published by the Zoological Society of London, and also appeared in the Annals and Magazine of Natural History. Carpenter did not write textbooks and his brother's memoir was based largely on material, often in shorthand, of a prolific letter writer. There is more work by Carpenter, mainly of a non scientific nature and not in bibliographies, which indicates that he produced a lot of written work before he began to write on conchological matters.

What of Carpenter's place in Natural History? Although he is highly regarded in North America, his reputation in Britain is not easy to assess. He achieved no academic position, although he applied for at least one, at Southampton (R. L. Carpenter, 1880). He appears not to have been conspicuously involved in national scientific societies, other than the British Association. Unlike his eldest brother, Benjamin, he was not a scientific man of affairs in the rapidly developing events of the mid-nineteenth century. Part of what seems to have been a solitary scientific life was offset by having numerous correspondents in Britain and North America. However, S. P. Woodward's letter to Darwin on 15th July 1856, referring to a Zoological Society meeting, mentions "Philip Carpenter joining in conversation", giving a clear impression that Carpenter was a well known naturalist amongst his peers (Burkhardt & Smith, 2000).

An early view of Carpenter was by Francis Newman (1805-1897), a teacher at Bristol College and later professor at University College, London. "I soon gained a perception how very transparent was his nature - guileless and ardent - a nature with which I had warm sympathy". Newman wrote , "when I heard of his eminence in natural history, I thought it to be a natural result of his youthful tendencies. From very early years he possessed the highly valuable quality of minute and persevering diligence, with great love of order and precision" (R. L. Carpenter, 1880).

Palmer, after years of research on Carpenter's shells, concluded that "he made himself an outstanding authority among the conchologisits of his day by his careful and persevering habits of analysis and comparison" (Palmer, 1972). Dance (1986) described "the diligent and capable conchologist. Carpenter's work showed that the chances of discovering new and interesting shells were increased considerably by paying close attention to small and minute forms".

Coan (1969) summed up Carpenter's position in science in a sentence, " Carpenter made contributions to the concepts of species and variation within species, to nomenclatural, systematic, and curatorial techniques, and to biogeography".

Philip Pearsall Carpenter was not a great innovator nor an important scientific theorist. In an age of many naturalists and a few giants of science, he contributed to a limited field. However, Carpenter's importance in the history of North American conchology can not be overstated. His seminal publications on the molluscs of the West Coast, with the descriptions of so many new species put in an historical context, are excellent and laid the foundations for malacology in that part of the world. He was also a highly industrious and honourable man and a naturalist who deserves to be remembered as a pioneer.

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DEEP-WATER GASTROPODS ENDEMIC TO LAKE BAIKAL - AN SEM STUDY ON PROTOCONCHS AND RADULAE

PETER RÖPSTORF[1] & FRANK RIEDEL[2]

Abstract *Lake Baikal, the deepest limnic water body on Earth is oxygenated throughout. This gave the ecological license to evolve a deep-water adapted malacofauna: Representatives of this fauna: 4 species of Hydrobiidae, including the only recently described* Yaroslaviella eximina *- 4 species of Baicaliidae, 2 species of Valvatidae, 2 species of Planorbidae, and 1 species of Acroloxidae were reinvestigated using SEM with emphasis on the protoconch and radula structure. Stomach contents were studied additionally in order to get a hint, from which resources these gastropods are living.*

Key words *Lake Baikal, deep-water, endemic gastropods, radulae, protoconchs.*

INTRODUCTION

Lake Baikal represents the most ancient lake of the world. It has a total length of 636 km, an average width of 40 to 50 km (maximum of 79.5 km) and contains more than 23000 km^3 of pure freshwater, which is about 20 percent of the world's freely available drinking water (Logatchev, 1993). There are two main basins, a northern and a southern one, which are separated by Olkhon Island, the peninsula of Svyatoy Nos and the connecting, diagonally striking subaqueous Academician ridge. The geologically older southern basin, with a depth down to 1637 m makes Baikal the deepest Lake on Earth. The north basin has a maximum depth of 920 m (Logatchev, 1993). About 300 rivers and rivulets open into the lake of which the Selenga represents by far the most important deliverer of water and sediments, its large delta contributing to the segmentation of the southern basin (Kozhova & Izmest´eva 1998).

Lake Baikal is well oxygenated throughout (Votintsev, 1961) which gave several metazoan taxa the opportunity to conquer even deepest regions. Kozhov (1963) subdivided the lake in depth zones, analogous to marine ecosystems, because of the extraordinary dimensions of Lake Baikal. The zone of 70-300 m on which we focus here, was regarded as "supra-abyssal" - a transmission zone between the sublittoral and the abyssal. Because of the steep shore this zone is rarely broader than 200-500 m in the western part of the lake. The zone maybe more extensive in the eastern and southern shore, particularly, where the larger rivers form their deltas.

Beside fish, crustaceans, "planaria", annelids, and sponges several representatives of gastropods have adapted to the "supra-abyssal".

The pioneers of investigation of the Baikalian fauna already mentioned so called giant forms in the deep-water zone; e.g. Gammaridae: B. Dybowski (1874), Garyaryev (1901), Dorogostajsky (1930), Bazikalova (1945), Gastropoda: W. Dybowski (1875), Lindholm (1909), Kozhov (1936); Turbellaria: Korotnev (1912). Analogously, such a phenomenon is known from the Antarctic marine fauna. Usually it was related to the low temperatures and the reduced metabolic rates of the cold-blooded animals living there. Actually Lake Baikal represents a huge coldwater body, where in summer the maximum temperature of the uppermost water layers varies about 10°C only. The water temperature below 250 m is constantly about 3.5-3.6°C. The coldwater conditions require adaptations according to reproduction: in gastropods the embryogenesis and the ontogeny in general is extremely prolonged and the seasonality in reproduction is reduced (Sitnikova, Röpstorf & Riedel, 2001).

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[1] Institute of Geological Sciences, Section of Palaeontology, Freie Universität Berlin, Malteserstr. 74-100, Haus D, 12249 Berlin, Germany. E-mail: rpeter@zedat.fu-berlin.de

[2] Interdisciplinary Centre for Ecosystem Dynamics in Central Asia, Freie Universität Berlin, Malteserstr. 74-100, Haus D, 12249 Berlin, Germany. E-mail: paleobio@zedat.fu-berlin.de

TABLE 1

Deep-water species described from Lake Baikal; compiled using data from Kozhov, 1936, Bekman & Starobogatov 1975, Starobogatov & Sitnikova 1998, Sitnikova & Shimaraev, 2001, and own data. Taxa re-examined in this study in bold.

Taxon	Depth in m	Substrate	Known distribution
RISSOOIDEA HYDROBIIDAE BENEDICTIINAE			
***Benedictia fragilis* (W.Dybowski, 1875) s.l.**	20-200	sand, silt	both lake basins, but patchy distribution e.g. Kultuk and near delta of Selenga River
B. maxima (W. Dybowski, 1875) *B. maxima marisminus* Sitnikova 1987	20-180 20-180	sand, silt sand, silt	south basin, north basin, Maloe More
B. nana Bekman & Starobogatov, 1975	300-400	sand, silt	north basin, Sosnovka-Bay
***B. pumyla* (Lindholm, 1924)**	50-790	sand, silt	north basin, Frolikha Bay, Tukalaragda, Academician Ridge
B. shadini Bekman & Starobogatov, 1975	30-180	sand, silt	north basin, Onguren, Ireksokon
***Kobeltocochlea falsipumyla* Sitnikova, 2000**	50-540	sand	north basin, Academician Ridge, near Bolshoy Ushkany Island, Shegnanda
***Yaroslaviella eximina* Sitnikova, 2001**	100-260	sand, silt, stones	north basin, Academician Ridge
BAICALIIDAE *Baicalia carinata* (W. Dybowski, 1875) *B. carinata rugosa*	 10-100 7-100	 silt, sand sand, silt	 south basin and Maloe More, north basin
***Godlewskia godlewski* (W. Dybowski, 1875)** ***G. godlewski speciosa* (Kozhov, 1936)**	8-200 8-250	sand, silt sand, silt	south basin north basin, Maloe More, Ushkany Islands
***Godlewskia bacilliformis* (Kozhov, 1936)**	20-100	sand, silt	both basins, e.g. mouth of Sukhaya River
G. columella (Lindholm, 1909)	3-140	rock, stones	south basin
G. wrzesniowskii (W. Dybowski, 1875)	15-100	sand	south basin, e.g. Berkhin-Bay
***Koretnewia angigyra* (Lindholm, 1909)**	10-200	sand, silt	north basin, Maloe More, Cape Pokojniki, Onguren

***K. korotnevi* (Lindholm, 1909)**	10-100	sand, silt	north basin, e.g. Chivyrkuj-Bay, Maloe More, Frolikha-Bay
Pseudobaikalia cancellata (Lindholm, 1909)	20-100	sand, stones	north basin
P. jentteriana	15-100	sand, silt	north basin, Maloe More
T. clandestina Bekman & Starobogatov, 1975	240	sand, silt	south basin, near Slydyanka
Teratobaikalia nana (Lindholm, 1909)	10-100	sand, silt	north basin e.g. Olkhon-Gates, Chivyrkuj-Bay, Barguzin-Bay, Posolsky-Bay, near delta of Sukhaya River
T. producta (=*nana* var.) (Kozhov, 1936)	10-100	sand, silt	north basin
Parabaikalia flori (W. Dybowski, 1875) *P. flori kobeltiana*	5-100 5-100	sand sand	south basin, e.g. Kultuk, Slyudyanka northern Baikal, Maloe More
VALVATOIDEA VALVATIDAE ***Cincinna bathybia* (W. Dybowski, 1886)**	50-400	sand, silt	northern Baikal, e.g. Cape Bolsodey
C. laethmophila Bekman & Starobogatov, 1975	1380	sand, silt	southern Baikal, e.g. Listvenichnoe
***C. profundicola* Bekman & Starobogatov, 1975**	100-800	sand, silt	northern Baikal, patchy distribution
PLANORBOIDEA PLANORBIDAE PLANORBINAE ***Choanomphalus bathybius* Bekman & Starobogatov, 1975**	25-400	sand, silt	both basins, e.g. Sosnovka-Bay,
***C. planorbiformis* Bekman & Starobogatov,1975**	155-580	sand, silt	north basin, patchy distribution, e.g. Barguzin-Bay, Academician Ridge, Sosnovka-Bay
ACROLOXOIDEA ACROLOXIDAE ***Psdeudancylastrum frolikhae* Sitnikova & Starobogatov, 1993**	340-420	stones, pebbles	north basin, e.g. Cape Pokojniki, Frolikha-Bay

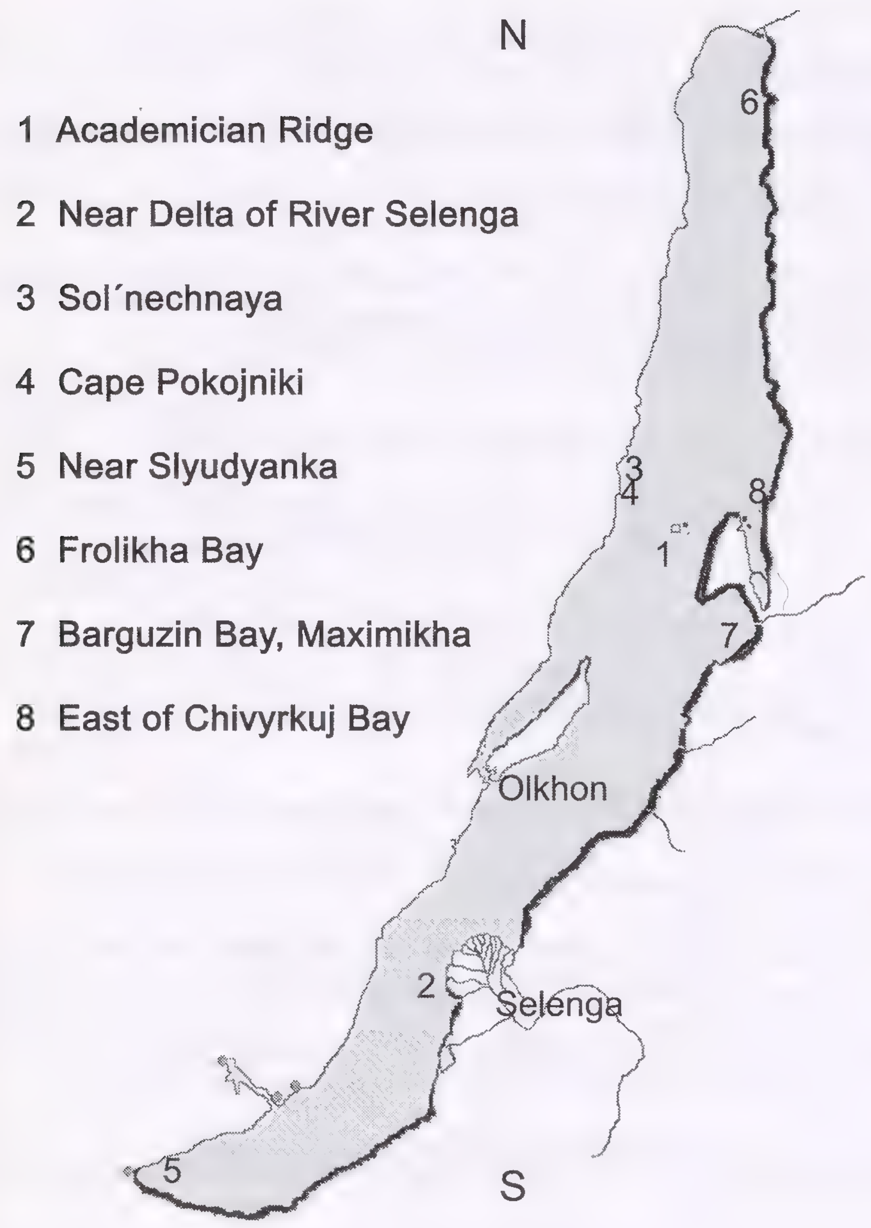


Figure 1 Schematic map of Lake Baikal with sampling sites

In the deep-water zone beside giant species also "dwarf"-forms have evolved (Kozhov, 1936, 1963, Sitnikova & Shimaraev, 2001). Relatively small species are realizing other ecological niches than the larger ones by using different microhabitats e.g. cracks or bases of stones, or even shells of large gastropods.

27 species of gastropods have been reported in literature to inhabit the deep-water zones of Lake Baikal, 10 of which are restricted in their distribution to these depths (see Table 1). Especially gastropods from hard substrate, from the steep slopes are seldom gathered and some deep-water species have only recently or not very long ago been discovered (Bekman & Starobogatov, 1975; Sitnikova, Fialkov & Starobogatov, 1993; Sitnikova, 2000, 2001). In most cases the number of gathered specimens was rather low and some of the species were described on the basis of two or three specimens only. The knowledge of some species is as yet restricted to the form of the teleoconch and detailed studies on the protoconch or the radula are missing or are of poor quality respectively. The aim of this study is to provide detailed documentations of the ultrastructural characters of protoconchs and radulae and to add some ecological data.

MATERIAL AND METHODS

Living gastropods were collected from the deep-water zone with the aid of a dredge or grab during different expeditions from 1995-2000. The sites are marked on the map of Lake Baikal (fig. 1). In 2000, when samples were taken from the Academician Ridge during an expedition of the research vessel "Vereshchagin" of the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences (LIN SB RAS), living gastropods could be photographed using an OLYMPUS OM2 camera mounted on a MBS-10 binocular microscope. Material of previous expeditions and also from other localities, stored at the LIN SB RAS, was used for comparison.

Gastropod specimens were fixed in 70% ethanol or in 2.5% glutaraldehyde solution. In respect of a detailed examination, the shells were cleaned by ultrasound. Additional treatment with sodium-hypo-chlorite was necessary with regard to shells, which were densely covered by diatoms and organic matter. Afterwards the shells were washed with demineralised water, dried and mounted on stubs. Stomach and intestine contents were washed in demineralised water, brought onto stubs, dispelled with the aid of preparation needles, and air-dried. Overall examination of shells was conducted using a MBS-10 binocular microscope with scales. Detailed examination of protoconchs, radulae, stylets, and stomach contents was carried out using a Cambridge 360 SEM (Scanning Electron Microscope). The shell of *Benedictia fragilis* was photographed using a NIKON macro objective.

The investigated specimens are stored in the ZMB, the Museum of Natural History, Humboldt University Berlin (formerly Zoologisches Museum Berlin).

The term 'protoconch' can be applied here to the embryonic shell, since all Baikalian gastropods do not have free larvae and hence no larval shells. In addition to the description of their sculpture, four measurements are given: number of whorls, maximum diameter, maximum width of the nonspiral (see Riedel 1993) and the height from the apex to the end of the aperture. Fig. 2 shows which measurements were taken.

Abbreviations: H = height, HA = height of aperture, HS = height of spire, L = length, n = number of specimens examined, sh = empty shells, sm = juvenile or adult specimens with soft parts, W = width, W1 = width of first whorl, W2 = width of second whorl, W3 = width of third whorl, WN = whorl number, WNS = width of nonspiral part of the protoconch.

RESULTS

RISSOOIDEA
HYDROBIIDAE (SEE REMARKS)
BENEDICTIINAE

Genus *Yaroslaviella* Sitnikova, 2001

Type species *Yaroslaviella eximina* Sitnikova, 2001

Yaroslaviella eximina Sitnikova, 2001

Yaroslaviella eximina Sitnikova, 2001: 499, figs. 1-3

Material examined 6 sm from Academician Ridge, 102-107 m depth, by dredge, on 13.8.1998. Museum number: ZMB/Moll. 103.115. 5 sm, from Academician Ridge, 100 –150 m depth, trawl with attached dredge, on 5.7.2000. Museum number: ZMB/Moll. 103.116a+b

Measurements Dimensions of largest teleoconchs in mm (except for NW):

H	W	HA	WA	HS	W1	W2	W3	NW
2.88	2.15	1.15	1.14	1.73	0.54	0.91	1.43	4.0
2.75	2.14	1.20	1.14	1.55	0.55	0.95	1.45	3.9

Dimensions of protoconchs in mm (except for NW); H measured in one specimen only

NW	WNS	W	H	n
1.7-1.80	0.14±0.01	0.79±0.03	0.57	10

Description **Teleoconch** Tiny, conic; ratio spire to shell height: 0.56-0.60; whorls well rounded and separated by a deep suture; umbilicus narrow but deep; aperture circular; operculum thin, not calcified, and a little smaller than aperture; sculpture: distinct axial ribs (15-20 per whorl) and fine spiral striae (fig. 3A & B); beside axial ribs, spirally arranged rows of pits are visible (fig. 3B).

Protoconch Differs from the later whorls by the sculpture: instead of fine rows of pits a reticulate structure formed by larger pits, lirae and pins is detectable (figs. 3C-E). Dense growth lines indicate the moment of hatching (fig. 3C, arrow). Nonspiral part (fig. 3D) relative narrow bearing only fine reticulate striae, which afterwards become prominent. Axial ribs missing.

Radula Taenioglossate; total length about 480 µm (from specimen with 4 shell

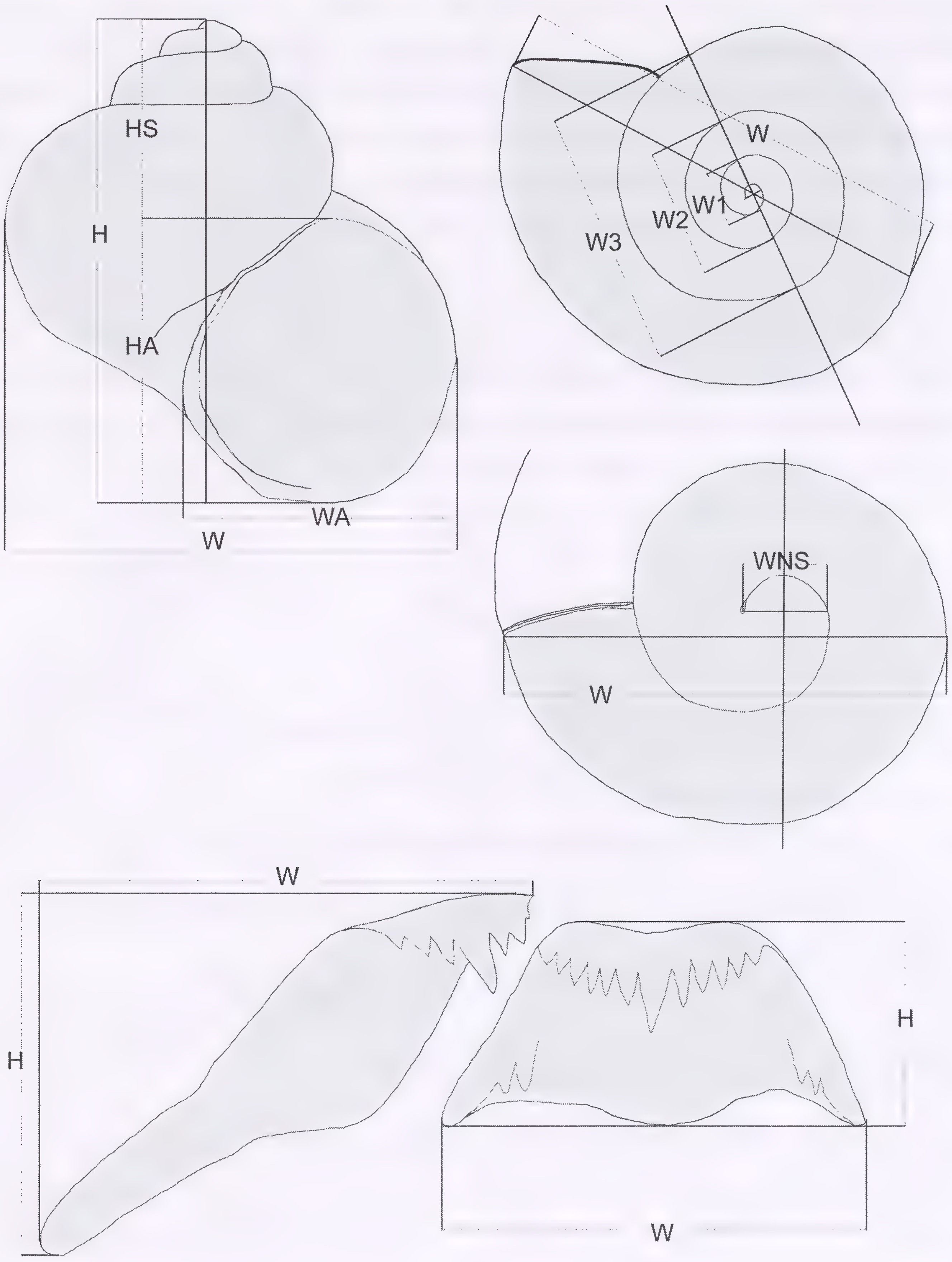


Figure 2 Scheme of gastropod measurements **2A** Measurements of the teleoconch; frontal view. Abbreviations: H = height, W = width, HS = height of spire, HA = height of aperture, WA = width of aperture. **2B** Measurements of the teleoconch; apical view: W = maximal width, W1 = width of 1. whorl, W2, width of 2. whorl, W3 width of 3. whorl. **2C** Measurements of protoconch; apical view. Abbreviations: WNS = width of nonspiral, W= width of protoconch.**2D** Measurements of teeth: H = height, W = width.

whorls), containing about 40 transverse rows of teeth; width about 90 µm (Marginals not spread) and 175 µm (Marginals spread) respectively. Central teeth of trapezoidal shape (W: 17-18 µm, H: 12 µm) with cutting edge bearing 6-13 cusps, the median of which is distinctly enlarged; basocones always present, their number varying from 2-5 on each side (fig. 3G). Laterals stout (fig. 3F & I) with an about 20 µm long lateral shaft (W: 30-33 µm, H: 27-30 µm); cutting edge with 10-15 cusps, one of which is a little enlarged (figs. 3I & J). Marginals slender (H= 40-45 µm, W= 7-8 µm), about 20 fine cusps (fig. 3F).

Stomach contents Planktonic diatoms *Cyclotella minuta* (fig. 3J) and *Aulacoseira baicalensis* (fig. 3J, arrows), Fungi and their spores (fig. 3K), as well as pollen from *Pinus* sp. (fig. 3H).

Other observations Body whitish-transparent; conglomerations of white pigment above black eyes (fig. 10A). Gonads and digestive system of largest specimen (a male) were invaded by trematodes.

Remarks The Benedictiinae were assigned into the large family Hydrobiidae (Kozhov, 1936, 1950, Ponder & Warén 1988). Other authors regarded them as a separate family, Benedictiidae (Lindholm, 1909, Sitnikova, 1987, 1995). According to anatomical (Kozhov, 1950) and recent molecular genetic studies (Hausdorf *et al*. 2003) they are closely related to the Lithoglyphinae. Probably these subfamilies should be separated from the Hydrobiidae but this will be the topic of further investigation.

The shape of the teleoconch of *Yaroslaviella eximina* is untypical for Benedictiinae but in respect of the characteristic reticulate sculpture of the protoconch, which is common for some species of *Benedictia* and for all species of *Kobeltocochlea*, we follow the taxonomic attribution by Sitnikova (2001). The radula feature "central teeth with basic cusps" occurring in *Yaroslaviella* as well as in most *Benedictia* and *Kobeltocochlea*, and the similarity of the female gonads, i.e. the presence of a gonoduct with bursa copulatrix and receptaculum seminis, are probably symplesiomorph because these characters can be found in many other hydrobian subfamilies too.

RISSOOIDEA
HYDROBIIDAE
BENEDICTIINAE

Genus *Kobeltocochlea* Lindholm, 1909

Type species *Hydrobia martensiana* W. Dybowski, 1875

Kobeltocochlea falsipumyla Sitnikova, 2000

Kobeltocochlea falsipumyla Sitnikova, 2000: 105, fig. 1, 2, 3a, 4, 5a-c

Material examined 7 sm, from Academician Ridge, 100 –150 m depth, trawl with attached dredge on 05.7.2000. Museum number: ZMB/Moll. 103.117a+b.

Measurements

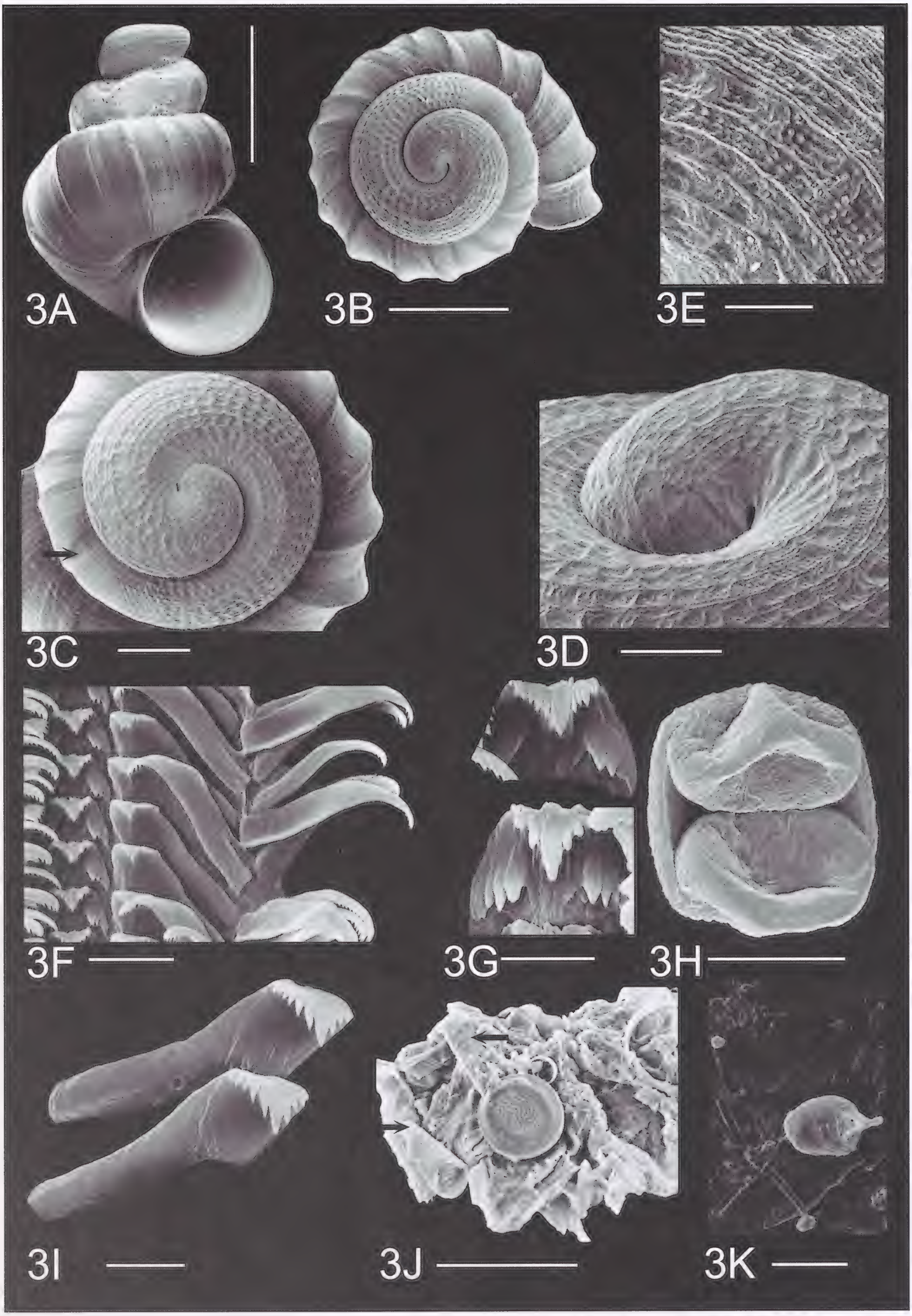
Dimensions of largest teleoconchs in mm (except for NW):

H	W	HA	WA	HS	W1	W2	W3	NW
5.4	5.10	3.1	2.8	2.3	0.64	1.37	2.65	3.9

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1.8-1.9	0.18±0.01	1.12±0.03	0.93	6

Description **Teleoconch** round-conic, yellowish or light brown; spiral striae distinct on all whorls (fig. 4A); umbilicus narrowly open; aperture broadly rounded (fig. 4A); operculum paucispiral and not essentially smaller than aperture. **Protoconch** very distinct reticulate sculpture (figs. 4B & C); transition from proto- to teleoconch characterized by dense growth lines (fig. 4B); nonspiral relatively broad, high-vaulted, and more or less smooth (fig. 4D). **Radula** taenioglossate; length about 1 mm (from specimen with 3.9 shell whorls) with 48-50 rows of teeth. Central teeth (W = 40-45 µm, H = 22-27 µm) bearing 2-3 basocones on each side (fig. 4F); cutting edge with 7-9 cusps, the mesocone of which is enlarged. Laterals (W = 72-80 µm, H = 42 µm) with cusped cutting edge (7 cusps with mesocone distinct larger as the others). Marginals (W = 15-17 µm, H = 80-100 µm) slender with cusps (fig. 4E). **Stomach contents** silty grains (covered by microorganisms), sponge spicules (*Baicalospongia* sp.), and valves of planktic diatoms (*Cyclotella* spp.). **Other observations** soft parts whitish; conglomerations of white pigment above black eyes and on tentacles; anterior end of foot pointed.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RISSOOIDEA
HYDROBIIDAE
BENEDICTIINAE
GENUS *Benedictia* W. Dybowski, 1875
Type species *Benedictia fragilis* W. Dybowski, 1875

Benedictia pumyla (Lindholm, 1924)

Kobeltocochlea pumyla Lindholm, 1924: 17
Kobeltocochlea pumyla Kozhov, 1936: 34
Benedictia pumyla Bekman & Starobogatov, 1975: 99, fig. 3V
Benedictia (Baicalocochlea) pumyla Sitnikova, 1987: 1471, fig. 4
Benedictia (Baicalocochlea) pumyla Sitnikova, 1995: 88, fig. 10a

Material examined 3 sm (largest sm with corroded apex was sectioned for radula study), from Academician Ridge, 100 –150 m depth, trawl with attached dredge, on 5.7.2000. Museum number: ZMB/Moll. 103.118.

Measurements
Dimensions of largest teleoconchs (apices corroded) in mm (except for NW):

H	W	HA	WA	HS	NW
8.2	6.9	4.7	4.2	3.5	4.25
10.3	8.0	5.5	4.9	4.8	4.6

Dimensions of protoconch in mm (except for NW):

NW	WNS	W	H	n
1.8	0.24	1.57	1.32	1

Description **Teleoconch** ovate-conic, yellowish or light brown; spiral striae distinct on all whorls; umbilicus narrowly open; aperture oval; operculum paucispiral and not essentially smaller than aperture. **Protoconch** moment of hatching indicated by dense, slightly thickened growth lines (fig. 5B, arrow); reticulate sculpture distinctly expressed (figs. 5A-C); nonspiral broad, with striae (fig. 5C & D). **Radula** taenioglossate; length about 2 mm, with about 40 transverse rows of teeth. Central teeth with 3-4 pairs of basocones; cutting edge bears 3 cusps, the median strongly developed (W: 82-95 µm, H: 50-60 µm). Laterals: hook-like with only remnants of a cusp on the inner side (W: 145-150 µm, H: 100-110 µm). Marginals: hook-like without any cusps; slender (W: 28 µm at the basis, tapering to the end; H: 160-170 µm). **Stomach contents** silt grains, sponge spicules and valves of planktic diatoms (*Cyclotella* spp.). **Other observations** soft parts whitish; white pigment above black eyes; anterior end of the foot rounded.

Remarks Although the shape of the teleoconch is very similar to that of *Kobeltocochlea*

Figure 3 *Yaroslaviella eximina* **3A** Teleoconch, frontal view. Scale bar: 1mm. **3B** Teleoconch of smaller specimen. Apical view. Scale bar: 0.5 mm. **3C** Protoconch. Apical view. Border between proto- and teleoconch marked by arrow. Scale bar: 0.2 mm. Scale bar: 0.2 mm. **3D** Nonspiral part of embryonic shell. Lateral view: Scale bar = 0.1 mm. **3E** Enlargement of the microsculpture – lirae, "pins", and pits - of the embryonic shell. Scale bar: 0.05 mm. **3F** Radular teeth. Scale bar: 0.02 mm. **3G** Central teeth with 2 (above) and 4 basocones from 2 different specimens. Scale bar: 0.01 mm. **3H** Stomach content: Pollen of *Pinus* sp. Scale bar: 0.02 mm. **3I** Lateral teeth. Scale bar: 0.01 mm **3J** Stomach content: Organic mass with diatom valves, the disc-like *Cyclotella minuta* and the cylindrical *Aulacoseira baicalensis* (arrow). Scale bar: 0.05 mm. **3K** Stomach content: Fungi (?). Scale bar: 0.01 mm.

falsipumyla (see below) this species can clearly be differentiated with the aid of radular and protoconch features.

Benedictia fragilis W. Dybowski, 1875

Benedictia fragilis W. Dybowski, 1875: 5, pl. 1, fig. 1-4, pl. 5, fig. 1-16, pl. 7, fig. 17- 19, pl. 8 fig. 1-4
Benedictia fragilis Westerlund, 1877: 93
Benedictia fragilis Crosse & Fischer, 1879: 149
Benedictia fragilis Westerlund, 1886: 88
Benedictia fragilis Lindholm, 1909: 32
Benedictia fragilis Kobelt, 1910: 40, fig. 2361
Benedictia fragilis Starostin, 1926: 15
Benedictia (Benedictia) fragilis Lindholm, 1927: 178
Benedictia fragilis Thiele, 1929: 145
Benedictia fragilis Kozhov, 1936: 46, pl. 10, fig. 4, pl. 11, fig. 7-10
Benedictia fragilis Zhadin, 1952: 242, fig. 179
Benedictia (*Benedictia*) *fragilis* Sitnikova, 1987: 1467, fig. 3, 9
Benedictia (*Benedictia*) *fragilis* Sitnikova, 1995: 82, fig. 11a

Material examined 3 sm, 7 sh, 5 hatchlings from egg-capsules, from east of Chivyrkuj Bay, 20 m depth, Beam Trawl, on 11.6.1996 (ex coll. Goddeeris). Museum number: ZMB/Moll. 103.119a+b. 2 sh, from near Delta River Selenga 70-100 m depth, 1998. Museum number: ZMB/Moll. 103.120. 3 sh, from near Delta River Selenga 100-150 m depth, 1988, ex coll. Zubina. Museum number: N 835 LIN

Measurements
Dimensions of large teleoconchs (apicis corroded) in mm (except for NW):

H	W	HA	WA	HS	NW
31.1	23.7	16.3	15.3	13.7	4.5-5
46.0	37.5	27.5	25.5	18.5	5.5
45.5	37.0	27.5	26.0	18.0	5.5
43.2	31.86	23.5	20.5	22.4	6.5
42.9	25.5	22.3	18.6	24.2	5.5
40.1	29.4	22.6	19.4	20.8	4.5

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1.8-2.0	0.17 ± 0.06	1.83±0.06	1.53±0.09	5

Description **Teleoconch** conic, very large (fig. 4G); aperture oval, its margin bended outwards in adult specimens; height of aperture exceeds height of spire; operculum reduced to about one quarter of aperture size. In relation to its large size, the shell is thin-walled (about 0.15 mm). **Protoconch** Dense growth lines mark moment of hatching; reticulate sculpture with spiral lirae, pits and pins (figs. 4H & I) comparatively weakly expressed; nonspiral (fig. 4I) very variable in width. **Radula** taenioglossate, comparatively large (L: 6.2-6.5 mm, W with spread marginals: 1.6 –1.7 mm); 44-48 rows of teeth. Central teeth broad trapezoidal (W: 210-240 µm, H: 125-160 µm), without basal cusps; cutting edge reduced to one large hook without clearly distinguished cusps (fig. 4K). Laterals (W: 370-410 µm H: 240-270 µm) as well as marginals (W: 80-85 µm, H: 420-450 µm) hook-shaped and without cusps (fig. 4J). **Stomach contents** no results. **Other**

observations eggs with fully developed embryos were found on a piece of wood and on the shells of *Benedictia fragilis* and probably can be attributed to this species.

Remarks The lack of basal cusps of the central teeth in *Benedictia fragilis* is not known from other Benedictiinae and in the context of other hydrobiids in which basal cusps are usually present, this feature has to be interpreted as apomorph.

Specimens from Northern Baikal were described as a subspecies *Benedictia fragilis distinguenda* Lindholm, 1909. Later it was regarded as a distinct species i.e. *B. distinguenda* (Sitnikova 1987, 1995). Another species close to *B. fragilis* was described as *B. pulchella* Sitnikova, 1987. Due to new statistical analysis of quantitative shell characters using primary data, these species can only be regarded as ecomorphs or phenotypes of *Benedictia fragilis* (Sitnikova pers. comm.).

RISSOOIDEA
BAICALIIDAE

Genus *Korotnewia* Kozhov, 1936
Type species *Baikalia korotnevi* Lindholm, 1909

Korotnewia angigyra (Lindholm, 1909)

Baikalia (Godlewskia) angigyra Lindholm, 1909: 64, pl. 1, fig. 56-58
Baikalia (Godlewskia) angigyra Starostin, 1926: 36
Baicalia (Korotnewia) angigyra Kozhov, 1936: 84, pl. 5, fig. 37-39
Baicalia (Korotnewia) angigyra Zhadin, 1952: 269, fig. 225
Korotnewia angigyra Sitnikova, 1991: 291

Material examined 1 sm from northern basin, western shore, Baikal-Lena Nature Reserve, near meteorological station "Solnechnaya"; 102 m depth, on grey sand with mud, taken by grab on 26.7.1996; ex coll. Takhteev & Röpstorf. Museum number: ZMB/Moll. 103.121

1 sm from northern basin, western shore, Cape Pokojniki; 109 m depth, on stones, taken by grab on 20.7.1996; ex coll. Takhteev & Röpstorf. Museum number: ZMB/Moll. 103.122

Measurements

Dimensions of teleoconchs in mm (except for NW):

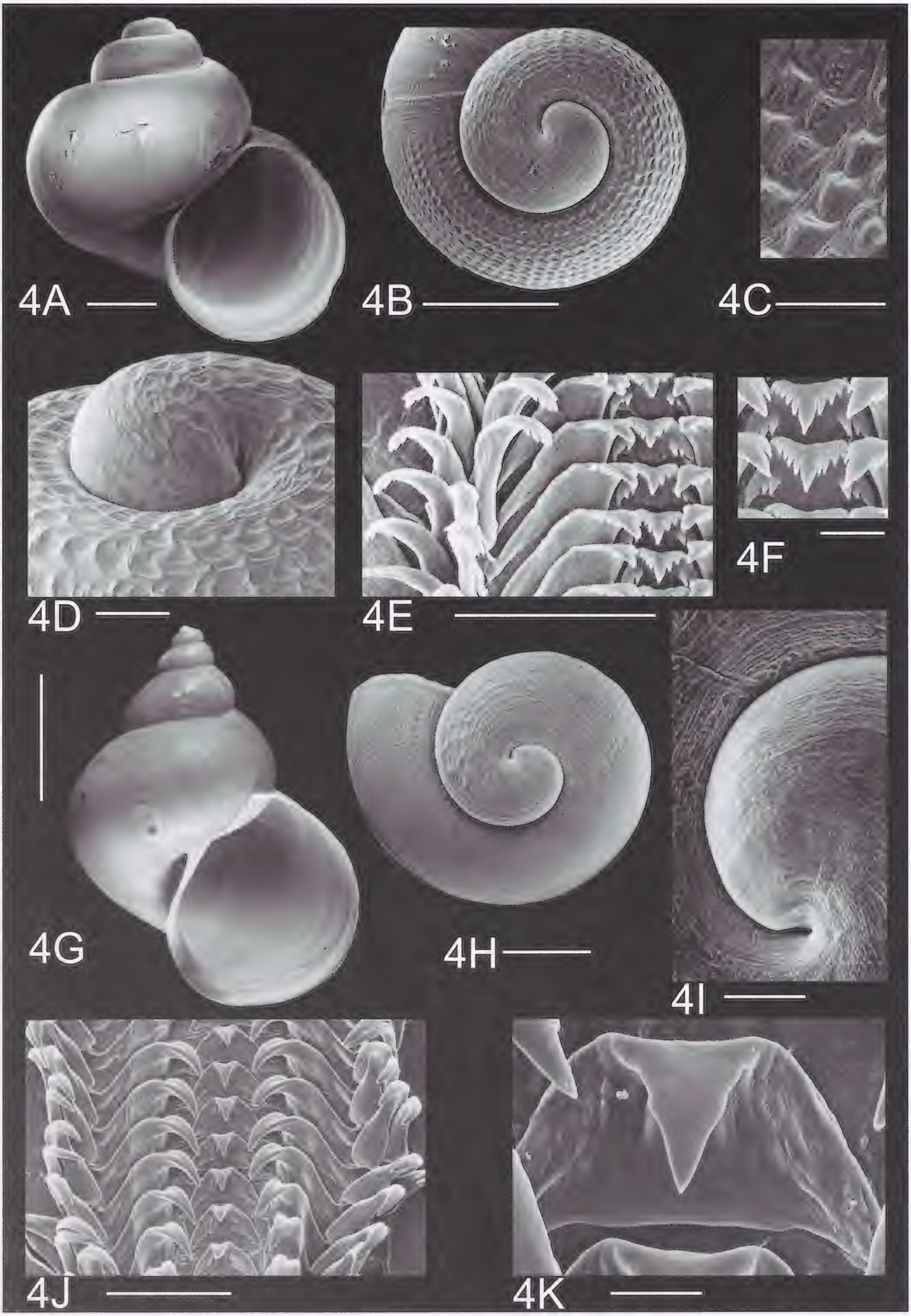
H	W	HA	WA	HS	W1	W2	W3	NW
5.9	2.7	1.7	1.5	4.2	0.48	0.62	0.88	6.6
4.5	2.2	1.4	1.2	3.1	0.47	0.65	0.84	5.75

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
2.1-2.25	0.165	0.72-0.80	0.80	2

Description **Teleoconch** turriculate; yellow or horn coloured, whorls well rounded with distinct spiral lirae (10-15) and up to 20 delicate striae (fig. 5K); aperture broad-oval, slightly angulated (fig. 5K); without umbilicus. **Protoconch** distinct spiral lirae present (10-15 on first whorl, seen from above); nonspiral high-vaulted, without lirae (fig. 5L); denser growth lines indicate moment of hatching at about 2.25 whorls (fig. 5M, arrow). **Radula** no data. **Stomach contents** no data.

Remarks Because only two specimens are at our disposal in which the soft parts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are deeply retracted, we decided not to destroy the shells and thus cannot provide information on radular and opercular features.

Which substrate *K. angigyra* prefers, remains unclear. Other expeditions of the Limnological Institut SB RAS obtained this species predominately from soft substrates in lower depths (50 m). The known area of distribution of this species is restricted to the northern basin of Lake Baikal including the Maloe More and Chivyrkui Bay.

RISSOOIDEA
BAICALIIDAE

GENUS *Godlewskia* Crosse & Fischer, 1897, nec Clessin
Type species *Ligea turriformis* W. Dybowski, 1875

Godlewskia godlewski

Leucosia Godlewskii W. Dybowski, 1875: 40, pl. 3, fig. 10-14, pl. 4, fig. 2a-d
Leucosia Godlewskii Westerlund, 1877: 96
Leucosia Godlewskyi Clessin, 1878: 133
Godlewskia ? godlewskii Crosse & Fischer, 1886: 156
Baikalia (Gerstfeldtia) godlewskii Kobelt, 1910: 61, fig. 2400-2401
Gerstfeldtia godlewskii B. Dybowski, 1911: 976
Baikalia (Gerstfeldtia) godlewskii Starostin, 1926: 38
Baikalia (Gerstfeldtia) godlewskii Kozhov, 1936: 112, pl. 4, fig. 32-36, pl. 12, fig. 13-16
Baikalia (Gerstfeldtia) godlewskii Zhadin, 1952: 276, fig. 237
Godlewskia godlewskia Sitnikova, 1991: 292

Material examined 11 sm (2 adults, 9 juveniles), from Academician Ridge, 100-150 m depth, by trawl with attached dredge, on 5.7.2000. Museum number: ZMB/Moll. 103.123.

Measurements
Dimensions of largest teleoconch in mm (except for NW); apical whorls missing, aperture partly broken; extrapolated data (based upon juveniles with apical whorls preserved) in parentheses:

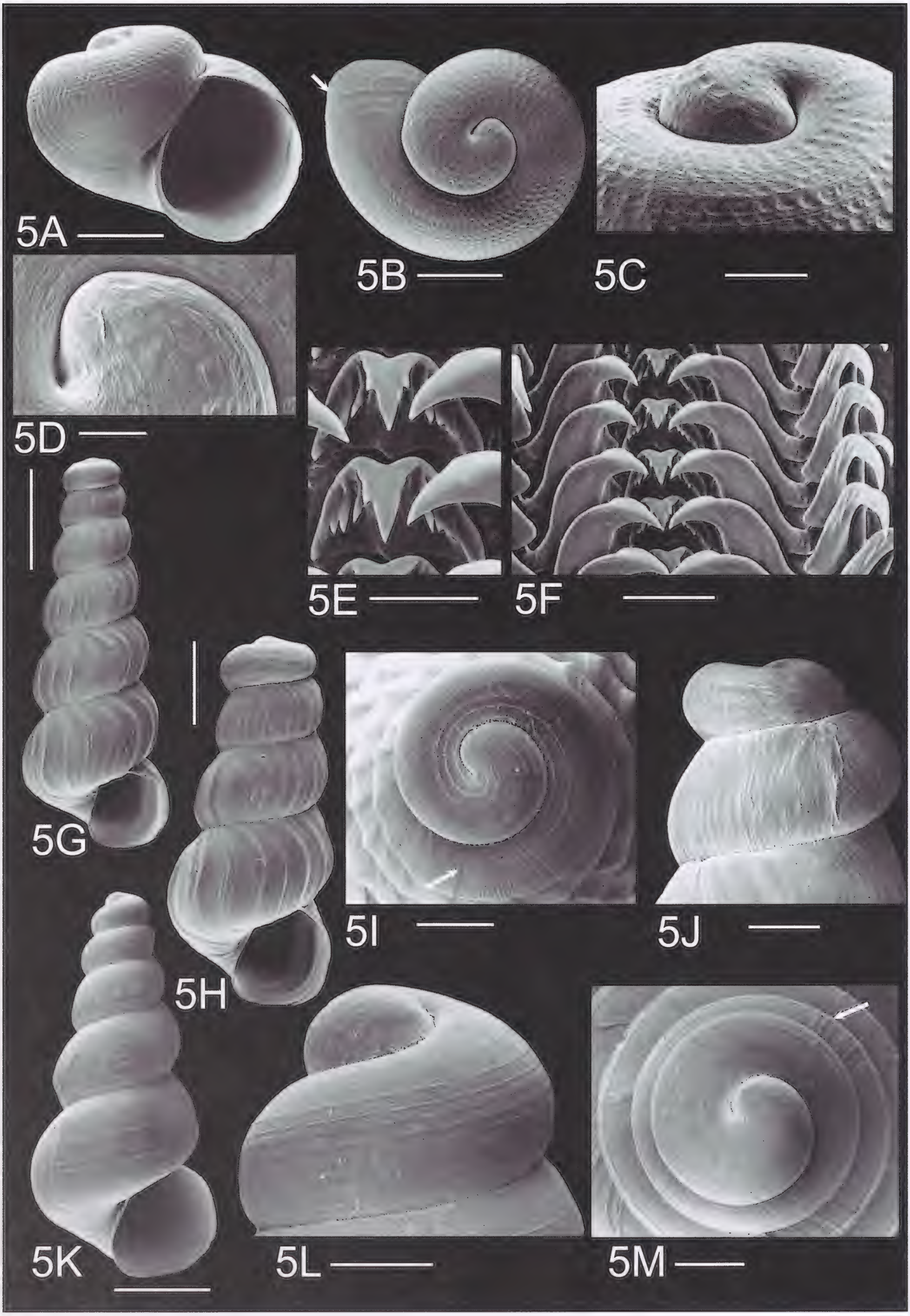
H	W	HA	WA	HS	W1	W2	W3	NW
15.9 (18.7)	4.0	2.7	2.0	16.0	(0.5)	(0.67)	(0.77)	10.2 (14.5)

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
2.6	0.13 ± 0.005	0.75 ± 0.02	-	3

Description **Teleoconch** light brown, very slender, turriculate (fig. 6A, juvenile, fig. 6B); first whorls rounded, but becoming flattened after 5-6 whorls (fig. 6B); 15-20 spiral lirae form short hair-like outgrowths of the periostracum (fig. 6E & F); where the suture forms a distinct keel is developed (fig. 6A). Aperture angulated; umbilicus closed. **Protoconch** high-vaulted nonspiral without sculpture; following part of embryonic shell exhibits

Figure 4 A-F: *Kobeltocochlea falsipumyla*; 4 G-K: *Benedictia fragilis* group **4A** Teleoconch. Frontal view. Scale bar: 1 mm. **4B** Protoconch (of a different specimen as in 4A). Apical view. Scale bar: 0.5 mm. **4C** Protoconch. Close-up of the microsculpture. Scale bar: 0.1 mm. **4D** Protoconch. Nonspiral. Lateral view. Scale bar: 0.1 mm. **4E** Radula. Scale bar: 0.1 mm. **4F** Central teeth. Scale bar: 0.02 mm. **4G** Teleoconch. Frontal view. Scale bar: 10 mm. **4H** Protoconch. Apical view. Scale bar: 0.5 mm. **4I** Protoconch. Nonspiral. Apical view: 0.1 mm. **4J** Radular teeth. Scale bar: 0.5 mm. **4K** Central tooth without basocones; cutting edge with one hook-like cusp. Scale bar: 0.05 mm.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spiral lirae; dense growth lines appear after 2.6 whorls, indicating moment of hatching; then periostracum outgrowths appear (figs. 6C-D). **Radula** taenioglossate, 0.75 mm long, 57 transverse rows of teeth. Central teeth (W: 24-27 µm, H: 11-12 µm) with broad, rounded cutting edge bearing 25-30 small cusps, the median slightly enlarged. Laterals (W: 30 µm, H: 20 µm) with about 30 small cusps (fig. 6G). Marginals slender, bearing multiple minor cusps. **Stomach contents** no data. **Other observations** animal may retract 4 whorls; body whitish, snout slightly reddish; yellow pigment above black eyes, protruding onto tentacles; foot very small, with thin and flexible operculum.

Remarks Specimens of *G. godlewski* bearing spiral lirae forming hair-like outgrowths from the northern basin of Lake Baikal were described by Kozhov (1936) as a subspecies *G. godlewski speciosa*.

The small foot may indicate that the species is not very mobile and in correspondence with the small finely cusped radular teeth it possibly lives by filter feeding or ingesting sedimented microparticles.

Godlewskia aff. *bacilliformis* Kozhov, 1936, sp. nov. ?

Baicalia (*Gerstfeldtia*) *bacilliformis* Kozhov, 1936: 110, pl. 3, fig. 31-33
Baicalia (*Gerstfeldtia*) *bacilliformis* Zhadin, 1952: 275
Godlewskia baciliformis Sitnikova, 1991: 292

Material examined 2 sm, from northern basin, western shore, Baikal-Lena Nature Reserve, near meteorological station "Solnechnaya"; 95 m depth, on grey sand with mud, taken by grab on 26.7.1996; ex coll. Takhteev & Röpstorf. Museum number: ZMB/ Moll. 103.124.

Measurements
Dimensions of largest teleoconch (probably juvenile) in mm (except for NW):

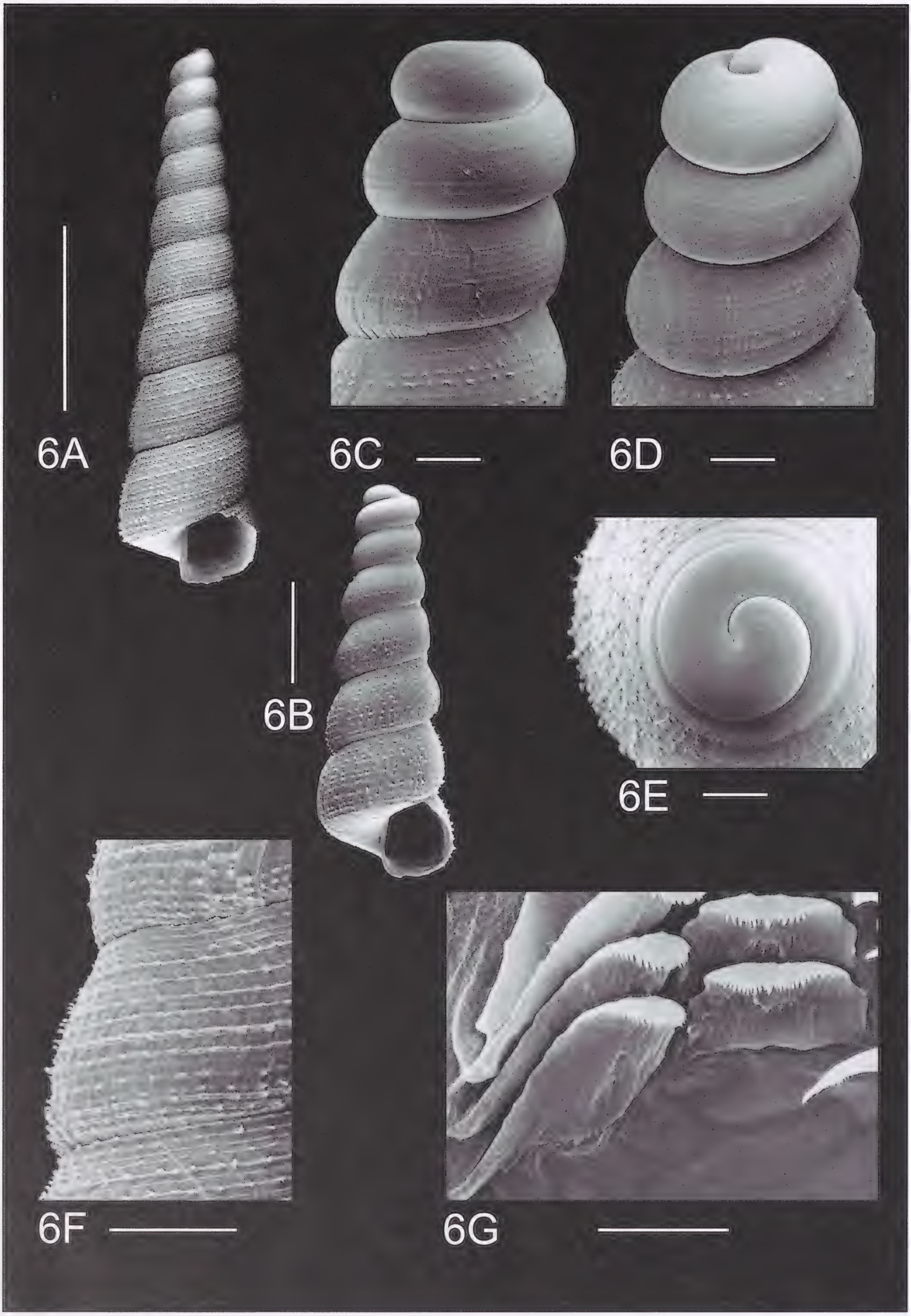
H	W	HA	WA	HS	W1	W2	W3	NW
4.20	1.5	0.77	0.81	3.43	0.42	0.63	0.71	7

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1.70-1.75	0.145	0.64-0.67	0.56-0.60	2

Description **Teleoconch** small, turriculate, whitish-light brownish; whorls flattened, bearing 19 slightly s-shaped axial ribs (fig. 5G & H); aperture broadly ovate and angulated; apex blunt. **Protoconch** about 1 3/4 well rounded whorls, bearing about 10 spiral lirae (fig. 5I); dense growth lines indicate moment of hatching (fig. 5I, arrow); protoconch axis and teleoconch axis forming a distinct angle (fig. 5J). **Radula** No data. **Stomach contents** No data.
Remarks The only described turriculate baicaliid species with regularly expressed

Figure 5 5A-F: *Benedictia pumyla.* 5G-J: *Godlewskia* aff. *bacilliformis,* sp.nov.? 5K-M: *Korotnewia angigyra.* **5A** Protoconch. Frontal view. Scale bar: 0.5 mm. **5B** Protoconch. Apical view. Scale bar: 0.5 mm. **5C** Protoconch. Nonspiral. Scale bar: 0.2 mm. **5D** Protoconch. Nonspiral. Scale bar: 0.1 mm. **5E** Radula. Central teeth with basal cusps. Scale bar: 0.05 mm. **5F** Radular teeth. Scale bar: 0.1 mm **5G** Teleoconch. Frontal view. Scale bar: 1mm. **5H** Teleoconch of smaller specimen. Frontal view. Scale bar: 0.5 mm. **5I** Protoconch. Apical view. Arrow points at transition to teleoconch. Scale bar: 0.2 mm. **5J** Protoconch. Lateral view. Initial whorl distorted. Scale bar: 0.2 mm. **5K** Teleoconch. Frontal view. Scale bar: 1 mm. **5L** Magnification of initial shell showing lirate microsculpture. Lateral view. Scale bar: 0.2 mm. **5M** Apical whorls. Arrow marks the probable border between proto- and teleoconch. Scale bar: 0.2 mm.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ribs are *Godlewskia wrzesniwskii* and *G. bacilliformis*. These, and also the non-ribbed *G. columella*, however show a protoconch type with 2.2-2.5 whorls (personal observation), which is at least half a whorl more than the specimens show presented in this study. It is thus likely that our specimens represent a new species. A proper description will be made when additional material has been sampled.

VALVATOIDEA GRAY, 1840
VALVATIDAE GRAY, 1840

Genus *Cincinna* Hübner, 1810
Type species *Valvata piscinalis* Müller, 1774

Cincinna bathybia (W. Dybowski, 1886)

Valvata (*Cincinna*) *bathybia* W. Dybowski, 1886: 129, pl. 4, fig. 2-4
Valvata (*Cincinna*) *bathybia* Westerlund, 1886: 135
Valvata (*Cincinna*) *bathybia* Lindholm, 1909: 74
Valvata (*Cincinna*) *bathybia* Kobelt, 1910: 20
Valvata (*Megalovalvata*) *bathybia* Kozhov, 1936: 29, pl. 1, fig. 45-47
Valvata (*Megalovalvata*) *bathybia* Zhadin, 1952: 217, Fig. 138
Valvata (*Megalovalvata*) *bathybia* Bekman & Starobogatov, 1975: 93, fig.1V
Cincinna (*Pseudomegalovalvata*) *bathybia* Sitnikova, 1983: 32
Cincinna (*Pseudomegalovalvata*) *bathybia* Sitnikova, 1993: 86, fig. 9b

Material examined 2 sm from southern basin, south-western shore of Lake Baikal, near Slyudyanka, 240 m depth, collected on 16.10.1970, ex coll. Bekman (material of LIN SB RAS). Museum number: ZMB/Moll. 103.125a+b.

Measurements
Dimensions of teleoconchs in mm (except for NW):

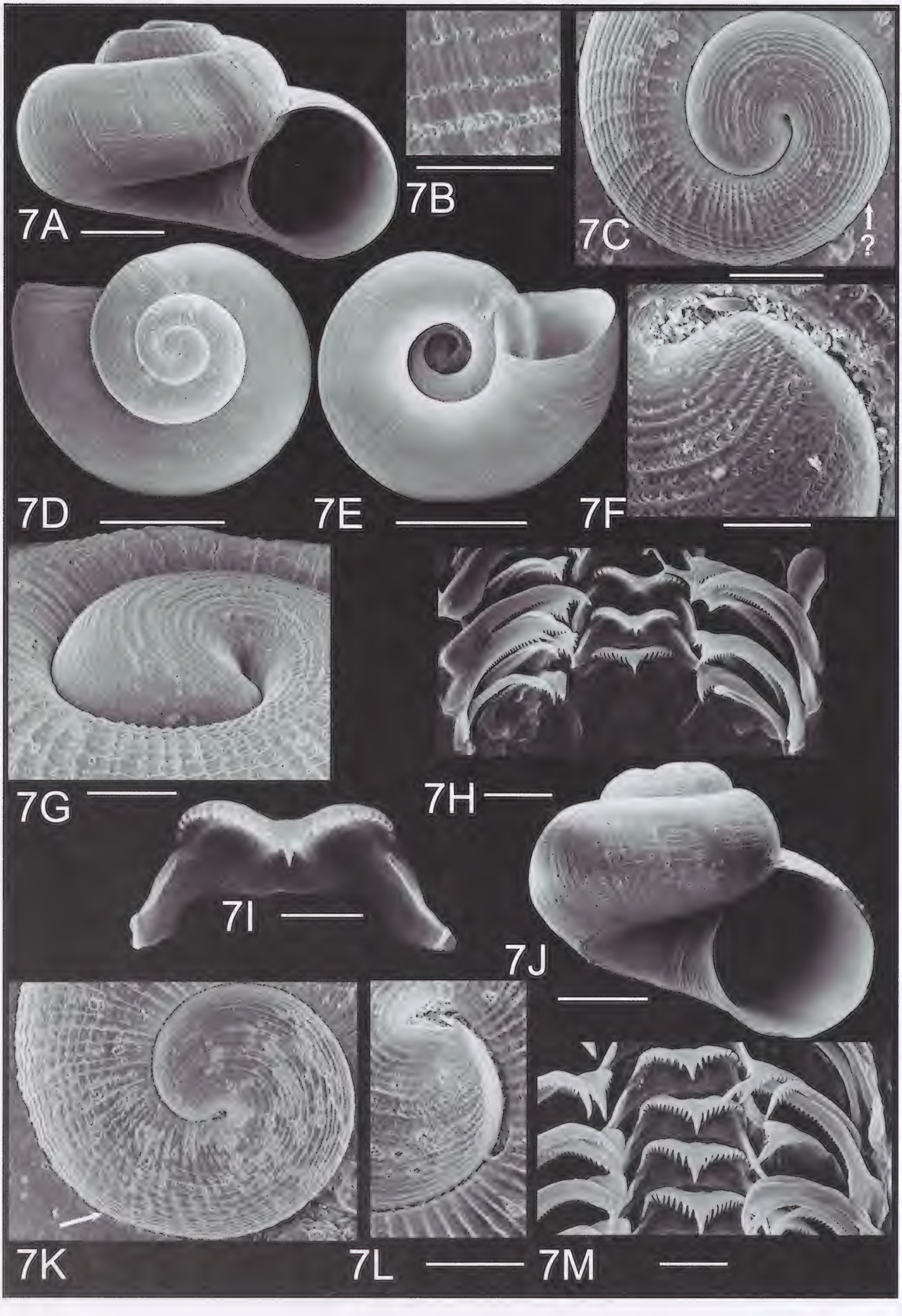
H	W	HA	WA	HS	W1	W2	W3	NW
1.70	2.28	1.04	1.01	0.66	0.53	1.18	2.23	3.1
1.51	1.97	0.91	0.89	0.60	0.52	1.12	-	2.9

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1	0.183 ± 0.004	0.50±0.02	?	2

Description **Teleoconch** cyrtoconoid-depressed, less high than wide, light brown to yellowish; spirally arranged rows of pits (modified continuation of protoconch lirae) (fig. 7K, arrow); umbilicus wide, bordered by a carina (fig. 7K, arrow); aperture circular. **Protoconch** transition from embryonic shell to first teleoconch whorl not clearly indicated; after 0.9 whorls first growth lines become distinct (fig. 7L); denser growth lines appear at 1.0-1.1 whorls and may indicate the moment of hatching; about 20 spiral lirae expressed; nonspiral asymmetric, with fine reticulate sculpture (fig. 7M). **Radula** taenioglossate, 0.2-0.25 mm long, 18-19 transverse rows of teeth. Central teeth (W: 45 µm, H: about 20 µm) with 20-25 cusps, the median of which is distinctly elongated (fig.

Figure 6 Baicaliidae, 6A-G: *Godlewskia godlewski*. **6A** Teleoconch with corroded apex. Scale bar: 5 mm **6B** Juvenile with apical whorls preserved. First whorls well rounded. Scale bar: 1 mm. **6C-D** Magnification of apical whorls in lateral view. Transition from protoconch to teleoconch. Scale bar: 0.2 mm. **6E** Protoconch. Apical view. Scale bar: 0.2 mm. **6F** Close-up of spiral lirae with periostracal hairs. Scale bar: 0.5 mm. **6G** Radular teeth. Scale bar: 0.02 mm.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7N). Laterals massive (W: 35 µm, H: 20-25 µm), with broad process bearing a cutting edge with about 30 cusps, one of which is broader and finger-like elongated. Marginals slender (W: 6-7 µm, H: about 50 µm); cutting edge with 30-40 cusps on the outer and 7-10 on the inner side; one cusp finger-like elongated (fig. 7N). **Stomach contents** sponge spicules (*Lubomirskia* sp.), diatoms (mainly *Cyclotella* spp.), amorphous detritus.

Cincinna profundicola (Bekman & Starobogatov 1975)

Valvata (*Pseudomegalovalvata*) *profundicola* Bekman & Starobogatov, 1975: 95, fig. 1g
Cincinna (*Pseudomegalovalvata*) *profundicola* Sitnikova, 1983: 32
Cincinna (*Pseudomegalovalvata*) *profundicola* Sitnikova, 1993: 86, fig. 9a

Material examined 10 sm from Academician Ridge, 100–150 m depth, by trawl with attached dredge, on 5.7.2000. Museum number: ZMB/Moll. 103.126.

Measurements

Dimensions of largest teleoconchs in mm (except for NW):

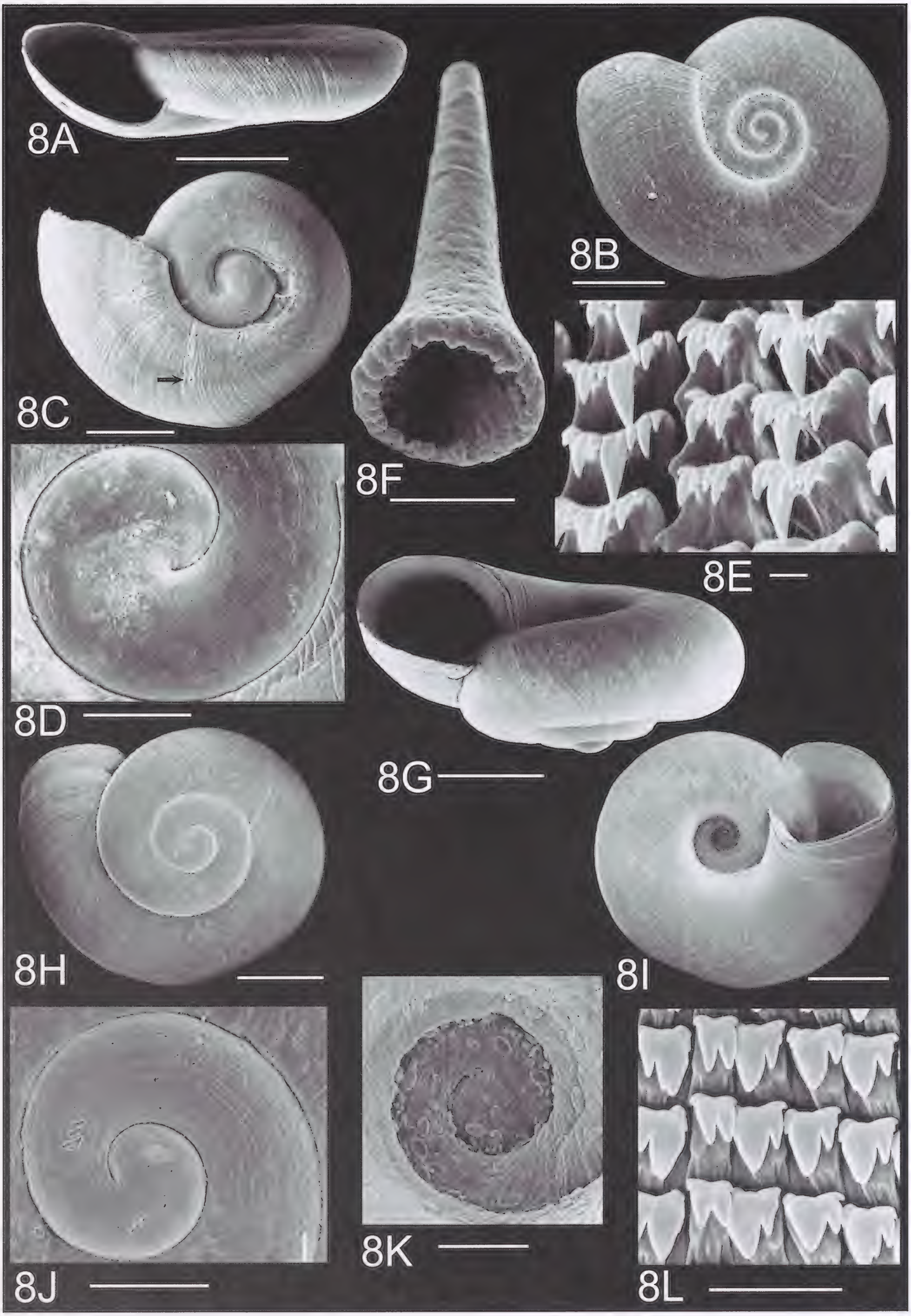
H	W	HA	WA	HS	W1	W2	W3	NW
1.47	2.24	0.96	0.96	0.51	0.51	1.15	2.29	3.25
1.34	2.22	0.88	0.89	0.46	0.49	1.13	2.25	3.1
1.70	2.57	1.13	1.05	0.57	0.50	1.15	2.30	3.3
1.43	2.27	1.01	0.93	0.42	0.50	1.16	2.28	3.1

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1-1.1	0.125 ± 0.013	0.49 ± 0.02	0.27	7

Description **Teleoconch** depressed, aperture height almost twice the height of spire, light brown to yellowish, (fig. 7A); first teleoconch whorl shows prominent reticulate sculpture, which continues from the protoconch (fig. 7C & D); the sculpture gets faint on following whorls, then expressed as delicate, spirally arranged rows of pits (fig. 7B); through the wide umbilicus all whorls can be seen (fig. 7E); aperture circular. **Protoconch** border between protoconch and teleoconch not always distinct; in some specimens dense growth lines at 1.0-1.1 whorls may indicate moment of hatching (fig. 7C, arrow); nonspiral part asymmetric, bearing fine reticulate sculpture, which becomes very prominent on the following embryonic shell (figs. 7F & G); about 20 spiral lirae expressed. **Radula** taenioglossate, about 0.2 mm long, 17-20 transverse rows of teeth. Central teeth (W: 34-40 µm, H: 18-19 µm) with 20-25 cusps, the middle of which is only a little longer than the others (fig. 7I). Laterals massive (W: 35 µm, H: 19 µm) with broad process; cutting edge with 20-23 cusps, one of which is broader (fig. 7H), but not finger-like elongated. Marginals slender (W: 7 µm, H: 40-47 µm); cutting edge with 30-40 cusps on the outer and 7-10 on the inner side. **Stomach contents** numerous valves of the planktonic diatoms *Cyclotella minuta* and *C. baicalensis*; few of the planktonic diatom

Figure 7 7A-I: *Cincinna profundicola*, 7J-M: *Cincinna bathybia*. **7A** Teleoconch. Frontal view. Scale bar: 0.5 mm. **7B** Magnification of teleoconch sculpture. Scale bar: 0.1 mm. **7C** Apical whorls with protoconch. Arrow points at probable transition to teleoconch. Scale bar: 0.02 mm. **7D** Teleoconch. Apical view. Scale bar: 1 mm. **7E** Teleoconch. Umbilical view. Scale bar: 1 mm. **7F** Protoconch. Nonspiral. Scale bar: 0.05 mm. **7G** Initial whorl with sculpture. Lateral view. Scale bar: 0.1 mm. **7H** Radular teeth. Scale bar: 0.02 mm. **7I** Radula. Central tooth. Scale bar: 0.01 mm. **7J** Teleoconch. Frontal view. Scale bar: 0.5 mm. **7K** Apical whorls with protoconch. Arrow points at probable transition to teleoconch Scale bar: 0.2 mm. **7L** Protoconch. Nonspiral. Scale bar: 0.1 mm. **7M** Radular teeth. Scale bar: 0.02 mm.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Aulacoseira sp.; a single benthic diatom; sponge spicules of *Lubomirskia* sp.; amorphous detritus; clastic sediments (grain size 0.05-0.1 mm).

Remarks Differences between *C. profundicola* and *C. bathybia* appear to be rather minute but these species can be distinguished with the aid of the general shell shape, which is more depressed in *C. profundicola,* the teleoconch carina in *C. bathybia*, the size of the nonspiral part of the protoconch, which is larger in *C. bathybia* and the shape of the median cusp of the central and lateral teeth, which is more distinct in *C. bathybia*.

PLANORBOIDEA
PLANORBIDAE
PLANORBINAE

Genus *Choanomphalus* Gerstfeldt, 1859
Type species *Choanomphalus maacki* Gerstfeldt, 1859

Choanomphalus bathybius Bekman & Starobogatov, 1975

Choanomphalus bathybius Bekman & Starobogatov, 1975: 104, fig. 4a

Material examined 2 sm from central Lake Baikal, eastern shore, Barguzin Bay off Maximikha, 25 m depth, sandy substrate, taken by dredge on 14.10.1995, ex coll. Sitnikova & Röpstorf. Museum number: ZMB/Moll. 103.127

Measurements
Dimensions of teleoconchs in mm (except for NW):

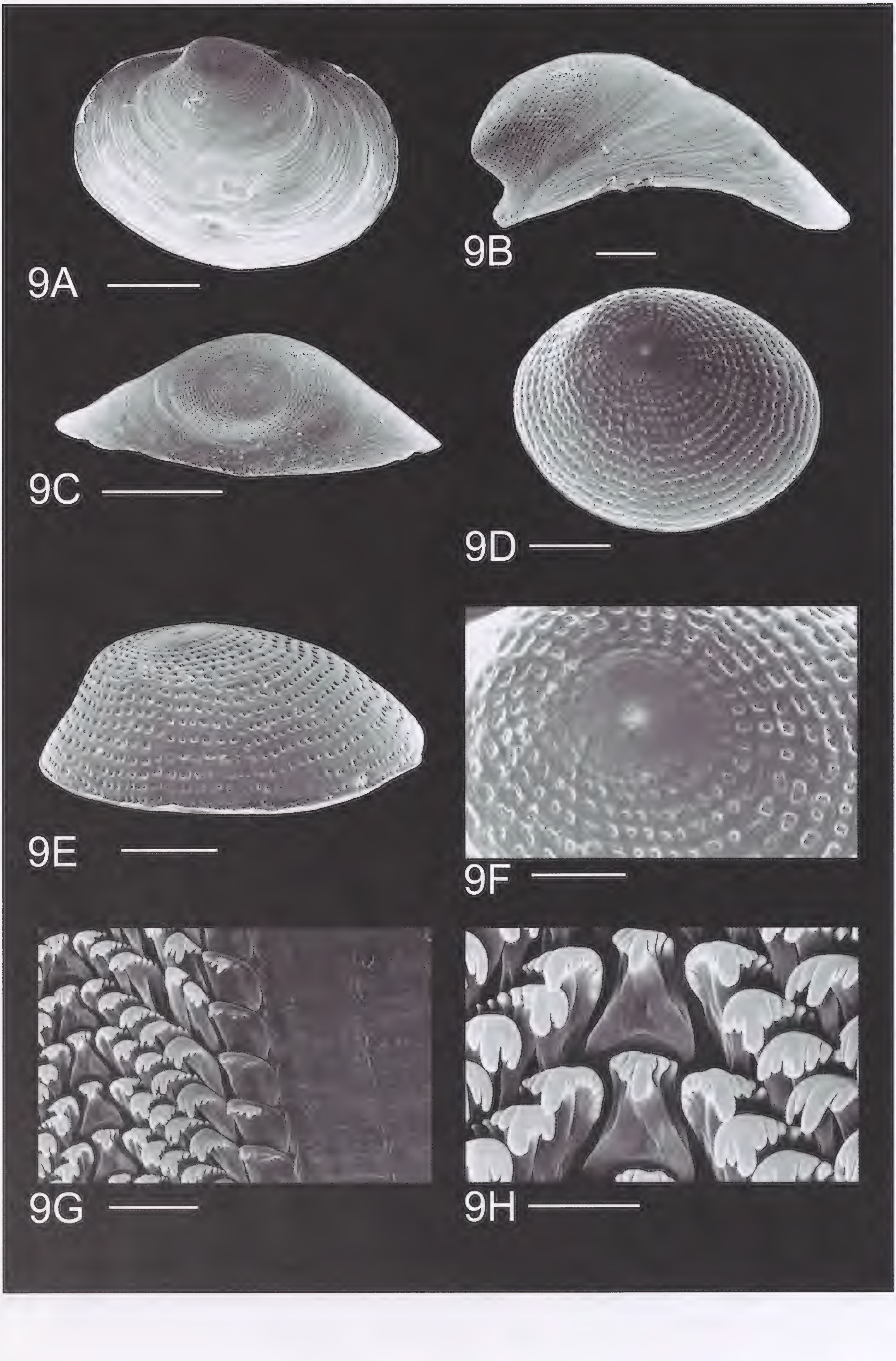
H	W	HA	WA	W1	W2	W3	NW
1.13	2.03	0.65	0.75	0.45	1.03	1.98	3.1
1.28	2.25	0.78	0.93	0.44	0.99	1.90	3.25

Dimensions of protoconchs in mm (except for NW):

NW	WNS	W	H	n
1.45-1.5	0.090 – 0.113	0.50-0.54	?	2

Description **Teleoconch** depressed hyperstrophic (fig. 8G), light brown; whorls regularly rounded, smooth, except for growth increments and infrequent spiral lirae near suture (fig. 8H); umbilicus wide, all whorls visible through it (figs. 8I & K); aperture ovate. **Protoconch** dense growth lines at 1.5 whorls indicate moment of hatching; about 15 distinct spiral lirae visible on apical side of first whorl (fig. 8J). **Radula** formula: 4-9-1-9-4; length: 0.79 mm, W: 0.14 mm, 120-130 transverse rows of teeth. Central teeth (W: 3.8 µm, H: 10 µm) with 2 main cusps and 2 small lateral cusps (fig. 8L). Laterals (W: 4.4 µm, H: 5.6-7.4 µm) with cutting edge broader than basis, asymmetric with 1 or 2 large and 4 or 5 small cusps (fig. 8L). Marginals (W: 3.2-3.5 µm, H: 6.1-6.6 µm) without cutting edge. **Other observations** penis stiletto 27-31 µm in length, with central canal, closed to

Figure 8 8A-E: *Choanomphalus planorbiformis*, 8F-L: *C. bathybius*. **8A** Teleoconch. Frontal view. Scale bar: 0.5 mm. **8B** Teleoconch. Apical view. Scale bar: 0.5 mm. **8C** Juvenile specimen. Protoconch. Arrow points at transition to teleoconch. Scale bar: 0.2 mm. **8D** Protoconch with spiral lirae. Scale bar: 0.1 mm. **8E** Radula. Central teeth and inner lateral teeth. Scale bar: 1 µm. **8F** Penis stiletto with anterior closed central channel. Scale bar: 5 µm. **8G** Teleoconch. Frontal view. Scale bar: 0.5 mm. **8H** Teleoconch. Apical view. Scale bar: 0.5 mm. **8I** Teleoconch. Umbilical view. Scale bar: 0.5 mm. **8J** Protoconch with spiral lirae. Apical view. Scale bar: 0.2 mm. **8K** Initial whorl in umbilical view. Scale bar: 0.1 mm. **8L** Radula. Central teeth and the inner 3 lateral teeth. Scale bar: 0.01 mm.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the tip; basis comparatively broad. (fig. 8F).

Remarks Prior to this investigation *Choanomphalus bathybius* was known only from deep-water. The 2 gathered specimens were determined as *C. bathybius* by T.Ya. Sitnikova.

Choanomphalus planorbiformis Bekman & Starobogatov 1975

Choanomphalus planorbiformis Bekman & Starobogatov 1975: 107, Fig. 4g

Material examined 2 sm (1 juvenile) from Academician Ridge, 100 –150 m depth, by trawl with attached dredge, on 5.7.2000. Museum number: ZMB/Moll. 103.128

Measurements
Dimensions of largest teleoconch in mm (except for NW):

H	W	HA	WA	W1	W2	W3	NW
0.50	1.74	0.44	0.65	0.35	0.77	1.69	3.1

Dimensions of protoconch in mm (except for NW):

NW	WNS	W	H	n
1.7	?	0.59	-	1

Description **Teleoconch** flattened, almost planispiral, with a countersunk spire (fig. 8A), whitish to transparent (fig. 10B; lower flank of whorls well-rounded, upper flank flattened; well-rounded flank with 10 distinct spiral lirae; growth increments pronounced; umbilicus wide, exhibiting all whorls; aperture broadly crescent-shaped. **Protoconch** nonspiral partly covered by subsequent whorl which is covered by about 10 spiral lirae on its apical side (fig. 8D); denser growth increments and increase of whorl diameter indicate moment of hatching (fig. 8C arrow). **Radula** formula: 10+1+10, at least 0.36 mm long (not completely preserved), 82-93 µm wide. Central teeth (W: 3.6 µm, H: 2.4-3.1 µm) with 6-7 cusps, the median two of which smaller than neighbouring cusps (fig. 8E). Lateral teeth (W: 4.5 µm, H: 3.6 µm) multicuspid, one cusp distinctly enlarged (fig. 8E); outer lateral teeth with reduced cutting edge. Marginal teeth are not differentiated. **Stomach contents** mainly the planktonic diatom *Cyclotella minuta*; amorphous cell mass with crushed diatom valves; chrysophycean cysts, the planktic diatom *Aulacoseira baicalensis* and sand grains were rarely contained. **Additional observations** body without pigmentation; light reddish appearance due to haemoglobin (fig. 10B); penis stiletto about 30 µm long, with central canal and a broadened base.

Remarks Radular teeth are characteristic regarding a higher number of cusps than is known from any other species of *Choanomphalus* described in this respect. This is quite remarkable because from the viewpoint of shell shape *C. planorbiformes* is plesiomorph (see discussion).

Figure 9 *Pseudancylastrum frolikhae* **9A** Teleoconch. Apical view. Scale bar: 0.5 mm. **9B** Teleoconch. Posterior view. Scale bar: 0.2 mm. **9C** Teleoconch. Lateral view (left side). Scale bar: 0.5 mm. **9D** Hatchling. Semi-apical view. Scale bar: 0.2 mm. **9E** Hatchling. Lateral view. Scale bar: 0.2 mm. **9F** Magnification of initial embryonic shell focussing central plate with pit and showing microsculpture. Scale bar: 0.1 mm. **9G** Radular teeth. Scale bar: 0.01 mm. **9H** Radula. Details of central teeth and inner lateralia. Scale bar: 5 µm.

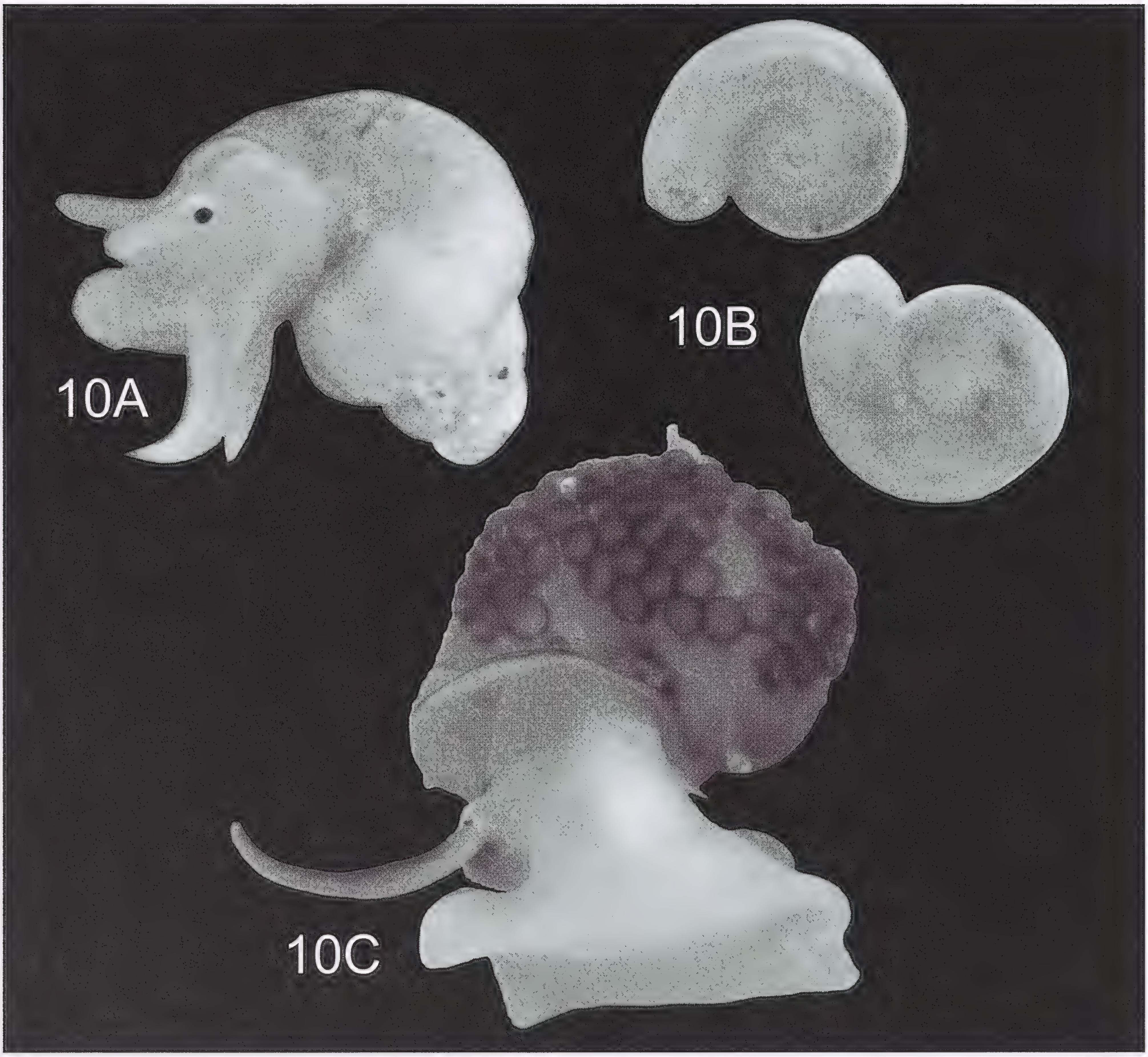

Figure 10 Living gastropods **10A** *Yaroslaviella eximina* **10B** *Choanomphalus planorbiformis* **10C** *Benedictia fragilis*

ACROLOXOIDEA THIELE, 1931
ACROLOXIDAE THIELE, 1931

Genus *Pseudancylastrum* Lindholm, 1909
Type species *Ancylus sibiricus* Gerstfeldt, 1859

Pseudancylastrum frolikhae Sitnikova & Starobogatov 1993

Pseudancylastrum (*Frolikhiancylus*) *frolikhae* Sitnikova & Starobogatov 1993: 134, fig. 1

Material examined 3 sm from western shore of northern basin of Lake Baikal, Baikal-Lena Nature Reserve, Cape Pokojniki, 109 m depth, from stones, by grab, 20.7.1996, ex coll. Takhteev & Röpstorf.

1 sm eastern shore of northern basin of Lake Baikal, Frolikha Bay, 340-360 m depth, from stones distributed on mud, sampled by submersible "Pisces" on 25.7.1990, LIN SB RAS. Museum number: ZMB/Moll. 103.129a+b

Measurements

Dimensions of teleoconchs in mm:

H	L	W
0.61	1.75	1.16

Dimensions of protoconchs in mm:

H	L	W	plate diameter
0.22	0.81	0.6	0.36
0.23	0.8	0.61	0.4
0.29	0.87	0.68	0.38

Description **Teleoconch** limpet-shaped, whitish, oval, with maximal width in the medium part; apex turned to the left, forming an angle of about 85° to the longitudinal axis (fig. 9A); projecting to or even over the left margin and lying only a little more distant from the anterior than from the posterior margin; aperture margin not plane, but bent wave-like (fig. 9B); ratio of aperture height to length of varies from 0.34 to 0.42. **Protoconch** more or less hemispherical, i.e. not horn-like protruding; apical portion with central small pit surrounded by a round plate lacking distinct sculpture (figs. 9D-F); further shell with rows of small pits which are clearly separated from each other (figs. 9 D). **Radula** formula: 2?-6-1+6+2?, 0.475 mm long, about 90 transverse rows of teeth, 0.1-0.11 mm wide. Central teeth (W: 5-5.1 µm, H: 5.9-6.0 µm) with broad basis; cutting edge exhibits 6-7 distinct cusps, the median enlarged (fig. 9H). Lateral teeth (W: 3.8-6.7 µm, H: 6-8.9 µm) bearing up to 11 small cusps and a single distinctly larger one (fig. 9H); outer laterals broad (6.7 µm) but with smaller cutting edge than inner ones, bearing only 3-4 cusps (fig. 9G). Marginal teeth largely reduced and difficult to differentiate.

Remarks This comparatively small species of *Pseudancylastrum* was originally described from a deep-water hydrothermal vent in Frolikha-Bay (northern Baikal, see fig.1). It is however not especially adapted to hydrothermal vents (Sitnikova *et al*. 2001), but to large depths, which could also be demonstrated here. In comparison to other *Pseudancylastrum*-species, the radula is not only smaller, but the teeth are also more delicately cusped. This could indicate that they are not scraping benthic diatoms, which is the main source of the other acroloxid species of Lake Baikal (Röpstorf *et al*. unpublished data) but ingest bacteria and fungi as well as decaying planktic diatoms.

The protoconch feature described here as "plate" is probably homologous with the nonspiral initial portion of non-limpet gastropods.

DISCUSSION

Sitnikova (2001) recognized 151 gastropod species living in Lake Baikal, 118 of which are endemic. 27 species enter greater depths but only 10 of these are actually true deep-water forms living below 100 m and are not found in shallow water zones. Considering that Baikal has existed continuously since the Late Oligocene (Mats, 1993) and taking into account that the lake is sufficiently oxygenated down to its greatest depths, the question arises why only a single gastropod species, the valvatid *Cincinna laethmophila*, lives in depths below 1000 m? It is a consensus among Baikal researchers that the lake has not always been so deep. Kuzmin, Karabanov, Bychinskyi, Kerber, Prokopenko, Yarmolyuk and Khomoutova (2001) estimated that Baikal has been a deep lake "only" since 7-6 my, however, without indicating depth ranges. The modern bathymetric distribution of gastropods may suggest that the extreme deepening of Baikal happened in the Quaternary. This is in correspondence with paleolimnological studies (Popova et al. 1989) and certain molecular data (Zubakov, Shcherbakov & Sitnikova, 1997) as well as with the hypothesis that the rate of plate rifting increased significantly from the Upper Pliocene on (Riedel, 2000b) and, probably, only in the Upper Pleistocene depths greater than 1000 m were reached. Consequently there would have been not so much time for gastropods to adapt to deepest water conditions. On the other hand habitats in 400 m or 1400 m depths do not really differ much from each other. Already in 400 m depth there is complete darkness and the water temperature below 250 m is generally 3.5-3.6 degrees Celsius, except for some hot vent spots in northern Baikal (Shimaraev & Verbolov, 1998).

In order to find the controlling parameter of bathymetric distribution, the deep-water gastropods themselves have to be analysed with regard to their evolutionary ecology. From the viewpoint of functional morphology caenogastropods, such as the hydrobiids and baicaliids have to be differentiated from heterobranch gastropods, represented by the valvatids, and from pulmonate gastropods such as the planorbids and the acroloxids. The valvatid *Cincinna laethmophila* has been caught from the greatest depths of the southern basin (see Table 1), which was about 600 m deeper than any other gastropod found in the lake. Second with regard to maximum depth are another species of the genus *Cincinna* and the caenogastropod *Benedictia pumyla*, which were collected from about 800 m depth. Down to almost 600 m not only the caenogastropod baicaliid *Kobeltocochlea falsipumyla* was found but also the pulmonate *Choanomphalus planorbiformis*. Two more pulmonates, *Choanomphalus bathybius* and *Pseudancylastrum frolikhae* may occur in depths of around 400 m. These examples may indicate that the differences in bathymetric distribution are somehow related to differences in respiratory organs. In particular, the valvatids have a larger (secondary) gill than the caenogastropods, which is completely missing in the pulmonates. Because oxygen is not a limiting factor in Lake Baikal, the gill could serve for a different purpose. Gills may also be used for filter-feeding (mainly planktic diatoms) and this could mean that species with comparatively larger gills are more efficient in collecting food. For some baicaliid species (e.g. *Baicalia turriformis*, *Teratobaikalia ciliata*) inhabiting the littoral, filter feeding has recently been documented (Röpstorf *et al.*, 2003). For the deep-water species it can be assumed as a way collecting micro particles from the water current. The food resources in Lake Baikal decrease with increasing depth. It is assumed that certain radular features, particularly the higher number of cusps in some deep-water species, represent special adaptations in order to collect microparticles from the sediment. This may represent a second important feeding strategy among baikalian gastropods.

The evolution of so-called gigantic gastropods appears to be linked directly with the food supply. *Benedictia fragilis*, as an example, represents the largest hydrobiid and even rissooidean worldwide. Recently, physiological studies have shown that low water temperature allows more oxygen to be dissolved in the blood (Chapelle & Peck 1999). Thus in cold water, animals have the ecological license to grow to large size, provided the food supply is sufficient. *Benedictia fragilis* is a facultative scavenger and thus occurs mainly where decaying invertebrates or fish (sculpins) can be detected in sufficient amounts (Sitnikova & Shimaraev, 2001, own observations) as for example sand banks near the deltas of larger rivers bringing organic matter into Lake Baikal and attracting fish and invertebrates. In its body-size and radula structure this species is well adapted to use this food source. The bathymetric distribution of *Benedictia fragilis* (50-200 m) demonstrates the optimal balance between cold water-temperature and food supply. The small sized gastropod species utilize micro particles such as decaying green algae, diatoms, bacteria, sinking down from the photic zone. According to Sitnikova & Shimaraev (2001) the small-sized deep-water species inhabit regions, which are characterized by a low food supply. This is particularly reflected by *Benedictia nana*, which lives deeper than *B. fragilis* and is much smaller. Actually there are no so-called gastropod giants living deeper than 200 m (compare Sitnikova & Shimaraev, 2001).

Nevertheless the great depths of Lake Baikal are directly related with gigantism because it produces the low temperatures, which are also effective in shallower water.

An adaptation of baikalian gastropods to deep-water can also be noted with regard to pigmentation of the body. Analogous to marine gastropods, which live in greater depths or within soft substrate (see Riedel, 2000a and references therein), it can be recognized that baikalian gastropods, which are living below the photic zone have reduced or even lost their pigmentation. Shallow water species are usually pigmented which probably represents a protection from UV-radiation. The impact of UVB-radiation (about 40 % in 5 m depth) in the clear waters of Lake Baikal appears to be significant in the upper 10 m (compare Calcins, 1982). In those species, which may occur in deep-water as well as in shallow-water, significant variation in pigmentation could be observed. In this context it is remarkable that in none of the investigated gastropods has reduction of eyes occurred, which is known to occur in deep sea and endobenthic marine gastropods. Riedel (2000a and references therein) documented that evolutionary age plays an important role with regard to such adaptation. Reduction of eyes appears to be a long-term process in gastropod evolution and may indicate additionally that Baikal reached its great depths in the course of the Quaternary only and thus the deep-water species have not lived long enough in the dark zone.

In respect of shell parameters reproduction strategies play a role.
It is evident that there is no general correlation between protoconch size and teleoconch size of gastropods (see Riedel, 2000a and references therein). A very large gastropod may exhibit a minute protoconch or a small gastropod may show a comparatively huge protoconch. With regard to baikalian gastropods it has been demonstrated (Röpstorf et al., 1998) that the largest protoconchs are found in species living in the littoral, i.e. *Benedictia baicalensis* and *Kobeltocochlea martensiana*. The embryos of Benedictiinae develop for 9-11 months within the egg capsule before they hatch as was observed in the case of *Benedictia baicalensis* (Sitnikova, Röpstorf & Riedel, unpublished data). Those of Baicaliidae need about 6 months (compare Sitnikova et al. 2001) to develop. This extreme prolongation, in comparison with non-baikalian relatives, is mainly controlled by the low water temperature. In correlation with large eggs huge embryos and thus protoconchs develop. In the deep-water species *Benedictia fragilis*, which is the largest baikalian gastropod, eggs and hatchlings are smaller than in *Benedictia baicalensis* inhabiting the littoral. It can be assumed that this is neither due to temperature effects nor to food shortage. *Benedictia fragilis* was only gathered from soft substrate and it was observed that the huge shells were densely covered by clutches of eggs, sometimes in 2 layers. Thus, the females use the shell of other specimens as substrate to attach their egg clutches. So it can be proposed that the smaller eggs might be correlated with the scarcity of hard substrate in greater depths, which the gastropods need in order to attach their capsules. This hypothesis is consistent with the observation that in *Benedictia pumyla*, which lives deeper (decreased availability of hard substrate with absence of large shells) than *B. fragilis*, the protoconch is smaller again.

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HARMOZICA OCCIDENTALIS NEW SPECIES FROM THE EASTERN PONTUS MOUNTAINS IN TURKEY (GASTROPODA: HYGROMIIDAE)

BERNHARD HAUSDORF[1]

Abstract Harmozica occidentalis *n. sp. from the eastern Pontus mountains in Turkey differs from* Harmozica maiae (Hudec & Lezhava, 1969), *its sister-species, in the weaker or obsolete granular sculpture, the smaller aperture, the usually lighter shell colour and the longer flagellum and more distal insertion of the appendiculae at the vagina.*

Key words *Harmozica, Hygromiidae, systematics, Turkey*

INTRODUCTION

The distribution area of the genus *Harmozica* Lindholm, 1927 extends from the eastern Pontus mountains in the west through the Caucasus region to northern Iran in the east (Schileyko, 1978). In the following a new *Harmozica* species will be described from the eastern Pontus mountains in Turkey.

MATERIAL AND METHODS

The counting of the shell whorls (exactness 0.25) follows Kerney & Cameron (1979: 13).

The material on which this study is based is kept in the following collections: IZPAN, Polska Akademia Nauk, Instytut Zoologii, Warszawa; NBE, Collection E. Neubert; NNM, Nationaal Natuurhistorisch Museum, Leiden; SMF, Senckenberg-Museum, Frankfurt a. M.; ZMH, Zoologisches Museum der Universität Hamburg.
Additional abbreviations: D = shell diameter; H = shell height.

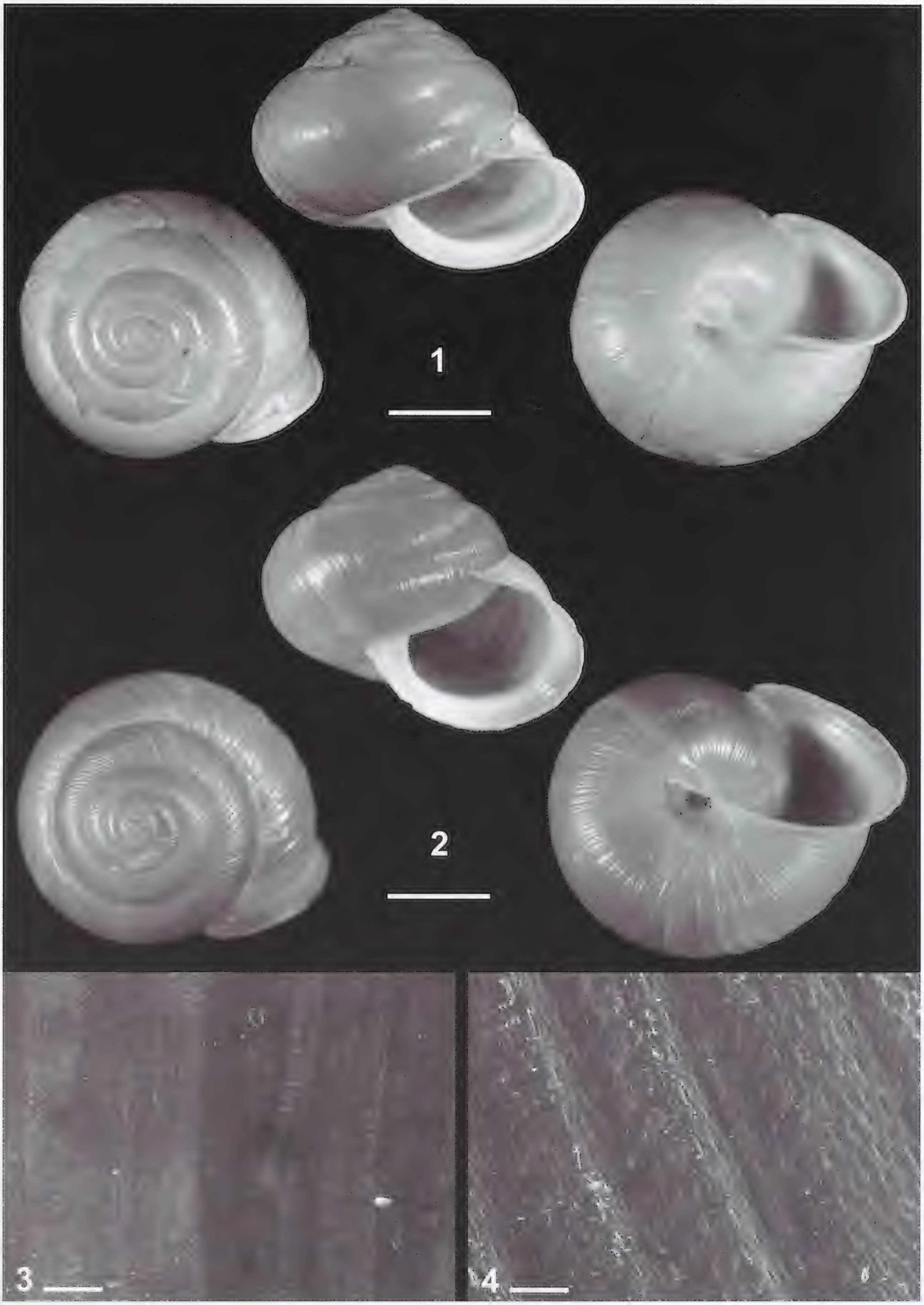
SYSTEMATIC DESCRIPTION

HYGROMIIDAE

Harmozica Lindholm, 1927

Remarks *Harmozica* is used in the sense of Schileyko (1978; under the name *Stenomphalia*, over which *Harmozica* has priority). *Harmozica* differs from *Euomphalia*, *Oscarboettgeria* and *Jasonella* in the lack of a membrane connecting the penial papilla with the penis wall. Furthermore, it differs from *Euomphalia* in the shorther appendiculae which do not rise above the terminal ends of the glandulae mucosae and the shell with a granular sculpture or spiral striae, but usually without hairs (however, *Euomphalia assadovi* Likharev & Rammelmeier, 1952, which is said to have hairs, has been placed in the synonymy of *Harmozica pisiformis* (L. Pfeiffer, 1852) by Schileyko (1978)). It remains doubtful, whether *Harmozica* is monophyletic, because clear autapomorphies of the genus are not known.

1 Zoologisches Museum der Universität Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany; email: hausdorf@zoologie.uni-hamburg.de



Figs. 1-4 *Harmozica* spp. **1** *Harmozica occidentalis* n. sp. Turkey: Monastery Sumelas (holotype SMF 323614). Scale bar = 5 mm. **2** *Harmozica maiae* (Hudec & Lezhawa). Georgia: Khala (ZMH 4435). Scale bar = 5 mm. **3** *Harmozica occidentalis* n. sp. Turkey: Monastery Sumelas (holotype SMF 323614). Microsculpture of the teleoconch. Scale bar = 0.1 mm. **4** *Harmozica maiae* (Hudec & Lezhawa). Georgia: Khala (ZMH 4435). Microsculpture of the teleoconch. Scale bar = 0.1 mm.

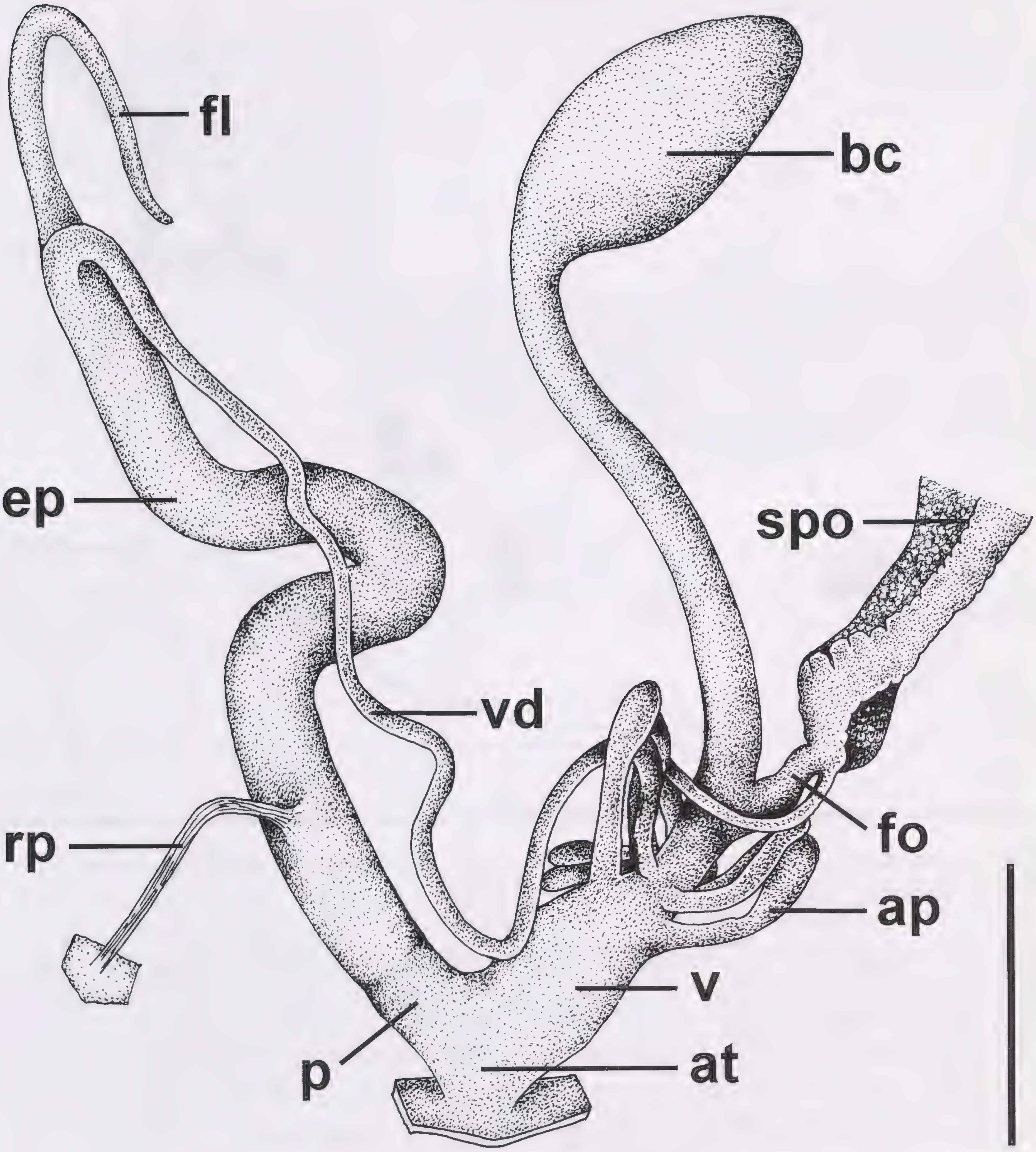


Fig. 5 *Harmozica occidentalis* n. sp., genitalia. Turkey: Monastery Sumelas (holotype SMF 323614). Abbreviations: ap = appendicula; at = genital atrium; bc = bursa copulatrix; ep = epiphallus; fl = flagellum; fo = free oviduct; p = penis; rp = penial retractor; spo = spermoviduct; v= vagina; vd = vas deferens. Scale bar = 5 mm.

Harmozica occidentalis n. sp.

Euomphalia (*Harmozica*) *appeliana* – Hudec, 1973: 248, text-fig. 8 [partim, non Mousson, 1876].
Euomphalia (*Harmozica*) *arpatschaiana* – Schütt, 1993: 347 [partim, non Mousson, 1873].
Harmozica appeliana – Schütt, 1996: 372 [partim, non Mousson, 1876].
Harmozica maiae – Schütt, 1996: 373 [partim, non Hudec & Lezhava, 1969].

Holotype Turkey: Vilayet Trabzon: Monastery Sumelas, 1150 m alt., UTM EF50 (SMF 323614, leg. E. Neubert 25.07.1988, measurements: D = 16.2 mm, H = 12.8 mm).

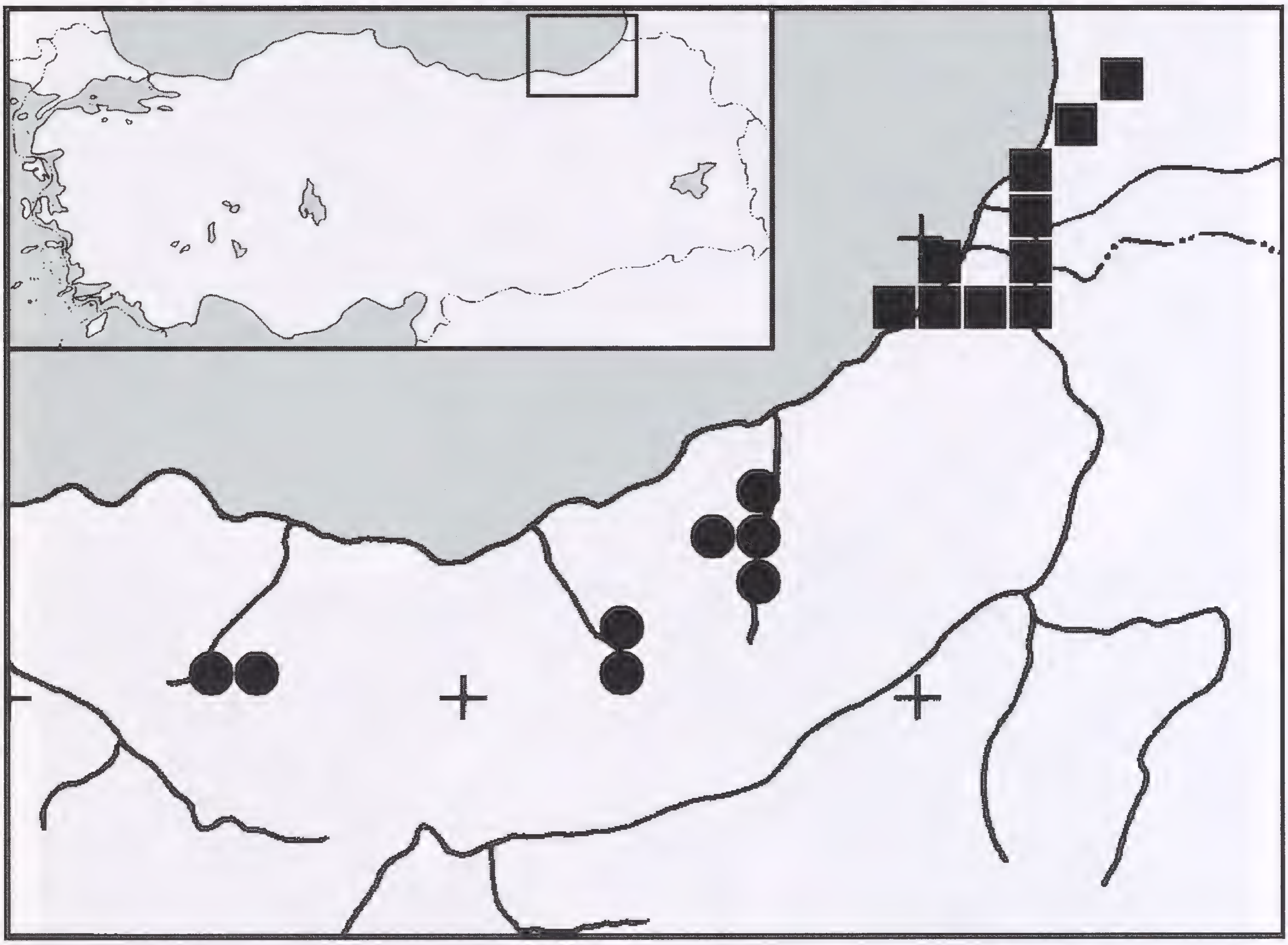


Fig. 6 Distribution of *Harmozica occidentalis* (●) n. sp. and *Harmozica maiae* (■)(Hudec & Lezhawa) (UTM-grid, 10 km - squares).

Paratypes **Turkey** Vilayet Trabzon: 3 km S of Hamsiköy, 1750-1900 m alt., EF40 (NNM 1583, specimens to Hudec, 1973); Monastery Sumelas, 1150 m alt., UTM EF50 (NBE; ZMH 4436). – Vilayet Rize: branch near Iyidere 50 km towards Ispir, 1200 m alt., UTM FF30 (NBE); Ikizdere 5 km towards Ispir, UTM FF31 (NBE); 15 km S of branch towards Katanpaşa, UTM FF53 (NBE); 21 km S of Çamlihemşin, 870 m alt., UTM FF62 (NBE); 12 km S of Çamlihemşin, 760 m alt., UTM FF63 (NBE); Çamlihemşin, UTM FF64 (IZPAN).

Type locality **Turkey** Vilayet Trabzon: Monastery Sumelas, 1150 m alt., UTM EF50.

Shell (Fig. 1, 3) depressed conical-globular; with 5-5.5 convex whorls; teleoconch with wrinkled growth-ridges and sometimes with a very fine and indistinct granular sculpture and/or indistinct incised spiral striae; yellowish or light brownish corneous, usually there is an indistinct whitish periphery band; body whorl rounded or with a slight blunt edge at the beginning; aperture elliptical; upper insertion of the peristome more or less distinctly descending; peristome sharp, distinctly expanded, with a whitish internal rib; umbilicus narrow or moderately narrow, partly or almost completely obscurred by the reflected columellar edge.

Measurements Various localities (n = 10): D: 13.3-16.2 mm, ø = 15.1 mm; H: 9.6-13.1 mm, ø = 11.5 mm; D/H: 1.21-1.39, ø = 1.32.

Genitalia (Fig. 5) The longish, terminally tapering penial papilla is not fixed at the

TABLE 1

Measurements of some sections of the genitalia of *Harmozica occidentalis* n. sp. and *Harmozica maiae* (Hudec & Lezhawa) (in mm). Abbreviations: ap = appendicula; ep = epiphallus; fl = flagellum; p = penis; v_{ap} = vagina up to the base of the appendicula; v_{gm} = vagina up to the glandula mucosae; v_t = total length of the vagina

	p	ep	fl	ap	v_{ap}	v_{gm}	v_t
Harmozica occidentalis							
Monastery Sumelas (holotype)	2.0	17.5	8.2	3.6	2.6	3.7	6.0
Çamlihemşin	1.9	10.0	5.0	3.2	3.2	4.3	5.6
Harmozica maiae							
Zelenyy Mys, Botanical garden	1.5	9.5	3.8	2.5	3.4	4	4.9
Zelenyy Mys, Botanical garden	1.9	12.2	3.8	2.5	3.7	4.2	5.4

TABLE 2

Comparison of the ratios of some sections of the genitalia of *Harmozica occidentalis* n. sp. and *Harmozica maiae* (Hudec & Lezhawa). Abbreviations: ap = appendicula; ep = epiphallus; fl = lagellum; p = penis; v_{ap} = vagina up to the base of the appendicula; v_{gm} = vagina up to the glandula mucosae; v_t = total length of the vagina

	ep: p	ep: fl	ep: ap	ep: v_t	v_t: v_{ap}	v_t: v_{gm}
Harmozica occidentalis	5.3-8.8	2.0-2.1	3.1-4.9	1.8-2.9	1.8-2.3	1.3-1.6
Harmozica maiae	6.3-6.4	2.5-3.2	3.8-4.9	1.9-2.3	1.4-1.5	1.2-1.3

penis wall by a membrane. There are longitudinal pleats inside the penial papilla which continue into the epiphallus. The slightly club-shaped terminal sections of the appendiculae are separated from the basal sections by indistinct incisions. There are four bifid glandulae mucosae. The bursa of the bursa copulatrix is more or less oval. The right ommatophoral retractor crosses between penis and vagina. The measurements of some sections of the genitalia are compiled in Table 1 and the variation of the proportions of some sections of the genitalia is compiled in Table 2.

Etymology This is the westernmost *Harmozica* species (Latin occidentalis = western).

Distribution (Fig. 6) *Harmozica occidentalis* is known from the northern slope of the eastern Pontus mountains (Doğu Karadeniz Dağları) in the vilayets Trabzon and Rize in Turkey.

Remarks *Harmozica occidentalis* is most closely related to *Harmozica maiae* (Hudec & Lezhava, 1969) (see Fig. 2, 4). For comparison two specimens of *Harmozica maiae* from the type locality, Zelenyy Mys east of Batumi in Georgia, have been examined anatomically (see Tables 1 and 2). *Harmozica occidentalis* differs from *Harmozica maiae* in the weaker or obsolete granular sculpture, the smaller aperture, the usually lighter shell colour and the longer flagellum and more distal insertion of the appendiculae at the vagina (see Table 3).

Harmozica occidentalis has been wrongly identified with the Caucasian *Euomphalia appeliana* (Mousson, 1876) by Hudec (1973). *E. appeliana* (Mousson, 1876) is an *Euomphalia* species with a different form of appendiculae (slender with a short, globose terminal section) and a larger shell with stronger wrinkled growth ridges, hairs or hair-scars and

TABLE 3

Comparison of the shell of *Harmozica occidentalis* n. sp. with that of conchologically similar species

	Harmozica occidentalis	*Harmozica maiae*	*Harmozica pisiformis*	*Euomphalia appeliana*	*Monacha laxa*	*Circassina frutis*
sculpture	wrinkled growth-ridges; sometimes a very fine and indistinct granular sculpture and/or indistinct incised spiral striae	wrinkled growth-ridges; distinct granular sculpture	wrinkled growth-ridges; distinct granular sculpture	strong wrinkled growth-ridges; hairs or hair-scars; distinct spiral striae	wrinkled growth-ridges and indistinct incised spiral striae	indistinct wrinkled growth-ridges and indistinct incised spiral striae
colour	yellowish or light brownish corneous	brownish corneous	brownish corneous	brownish corneous	pale yellowish corneous	yellowish or brownish corneous
peristome	distinctly expanded	distinctly expanded	slightly expanded	slightly expanded	± distinctly expanded	distinctly expanded
umbilicus	narrow or moderately narrow, partly or almost completely obscurred by the reflected columellar edge	narrow or moderately narrow, partly or almost completely obscurred by the reflected columellar edge	moderately narrow, partly obscurred by the reflected columellar edge	moderately wide, partly obscurred by the reflected columellar edge	very narrow, almost completely obscurred by the reflected columellar edge	narrow or very narrow, partly or almost completely obscurred by the reflected columellar edge
diameter	13.3-16.2 mm	13.5-19 mm	8-17 mm	17-20 mm	12.2-20.3 mm	13.7-24.6 mm

a wider umbilicus (see Table 3 and Schileyko, 1978; it should be re-examined whether *E. appeliana* (Mousson, 1876) and *E. aristata* (Krynicki, 1836) are really distinct and how they differ).

Schütt (1993) ignored Schileyko (1978) and placed *Euomphalia appeliana* (Mousson, 1876) as well as *Euomphalia appeliana* sensu Hudec (1973) in the synonymy of *Euomphalia arpatschaiana* (Mousson, 1873), a synonym of *Harmozica pisiformis* (L. Pfeiffer, 1846) (see Schileyko, 1978). *Harmozica occidentalis* differs from the conchologically similar *Harmozica pisiformis* in the weaker or obsolete granular sculpture and the slender appendiculae which are basally not swollen and the in relation to the epiphallus shorter flagellum (see Table 3).

Harmozica occidentalis is conchologically also similar to *Circassina frutis* (L. Pfeiffer, 1859) with which it occurs sympatrically in the eastern Pontus mountains. *Harmozica occidentalis* differs conchologically from that species in the, on average, smaller shell with usually more distinct growth-wrinkles, but less distinct incised spiral striae and sometimes with a granular sculpture and the on average smaller aperture with a more expanded peristome (see Table 3). *Harmozica occidentalis* differs from the conchologically similar *Monacha laxa* Hausdorf, 2000 which also occurs in the eastern Pontus mountains in the less depressed, more intensively coloured shell with more distinct growth-wrinkles and sometimes a granular sculpture and a wider umbilicus and a more expanded peristome (see Table 3).

ACKNOWLEDGEMENTS

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STATUS AND RELATIONSHIPS OF *VITRINA MUSIGNANI* PIRAJNO, 1842, AND *VITRINA PAULUCCIAE* FISCHER IN PAULUCCI, 1878 (GASTROPODA: PULMONATA: VITRINIDAE)

G. MANGANELLI & F. GIUSTI[1]

Abstract *Two nominal vitrinid species from Southern Italy and Sicily,* Vitrina musignani *Pirajno, 1842, and* Vitrina paulucciae *Fischer in Paulucci, 1878, are revised. The available data supports that they represent a single species belonging to the genus* Oligolimax *Fischer in Paulucci, 1878:* Oligolimax musignani.

This species constitutes the smallest species of Oligolimax *and is characterized by protoconch with a few pits near suture of first half whorl and fine, wavy, radial, rather widely and regularly spaced, irregularly branched periostracal crests; teleoconch with fine, radial, closely and regularly spaced ribs; genitalia with large wide glandula amatoria almost entirely covered by thick glandular layer.*

Key words Oligolimax musignani, *Vitrinidae, taxonomy, systematics, distribution, Sicily, Southern Italy.*

INTRODUCTION

In the recent checklist of Italian land snails (Manganelli *et al.*, 1995), two nominal species of the family Vitrinidae, *Vitrina paulucciae* Fischer in Paulucci, 1878, and *Vitrina polloneriana* frà Piero [Arbanasich], 1897, were the subject of concise comments because of their remarkable interest for the taxonomy and systematics of the vitrinids. In fact, study of syntypes of *V. paulucciae* (type species of *Oligolimax* Fischer in Paulucci, 1878) showed that Forcart (1965) was wrong in considering this species a junior synonym of *Vitrina bonelli* Targioni Tozzetti, 1873, and consequently in proposing *Semilimacella* Soós, 1917 (type species: *Vitrina velebitica* Soós, 1917, according to him a junior synonym of *V. bonelli*), *Targionia* Hesse, 1923 (type species: *V. bonelli*) and *Tozzettia* Hesse, 1924 (new name for *Targionia* Hesse, 1923) as junior synonyms of *Oligolimax*. Moreover, anatomical study of *V. paulucciae* showed a striking similarity in genital structure between it and some species assigned to *Gallandia* Bourguignat, 1880 (type species: *Vitrina conoidea* Martens, 1874, *sensu* Bouguignat, 1880, i.e. *G. olympica* Hausdorf, 1995) and *Insulivitrina* Hesse, 1923 (type species: *Helicolimax lamarckii* Férussac, 1821), suggesting that these two genera were junior synonyms of *Oligolimax*. With regard to *V. polloneriana*, the few anatomical datails available support affinity with *Oligolimax* though more study was required to decide whether to include it in this or in a distinct genus close to *Oligolimax*.

A third nominal species, *Vitrina musignani* Pirajno, 1842 (pp. 157-158); (type locality: "... nelle alture delle Caronie, nell'ex feudo di Levanche, sotto il fogliame caduto in parti umide" [on the Caronie mountains, in the ex-feud named Levanche, under litter in damp sites]; "Caronie" is an old name for the Nebrodi Mountains) is also very important for the taxonomy of the family being the oldest established Italian vitrinid species. L. Benoit, a well-known student of Sicilian malacofauna, initially regarded it as a valid species (Benoit, 1857-62, 1876) and later as a junior synonym of *Oligolimax annularis* (Studer, 1820) (Benoit, 1881), which is absent from Sicily. Westerlund (1886: p. 23) received some shells under the name of "*Vitrina musignani* Pir.", collected in "Sicilien

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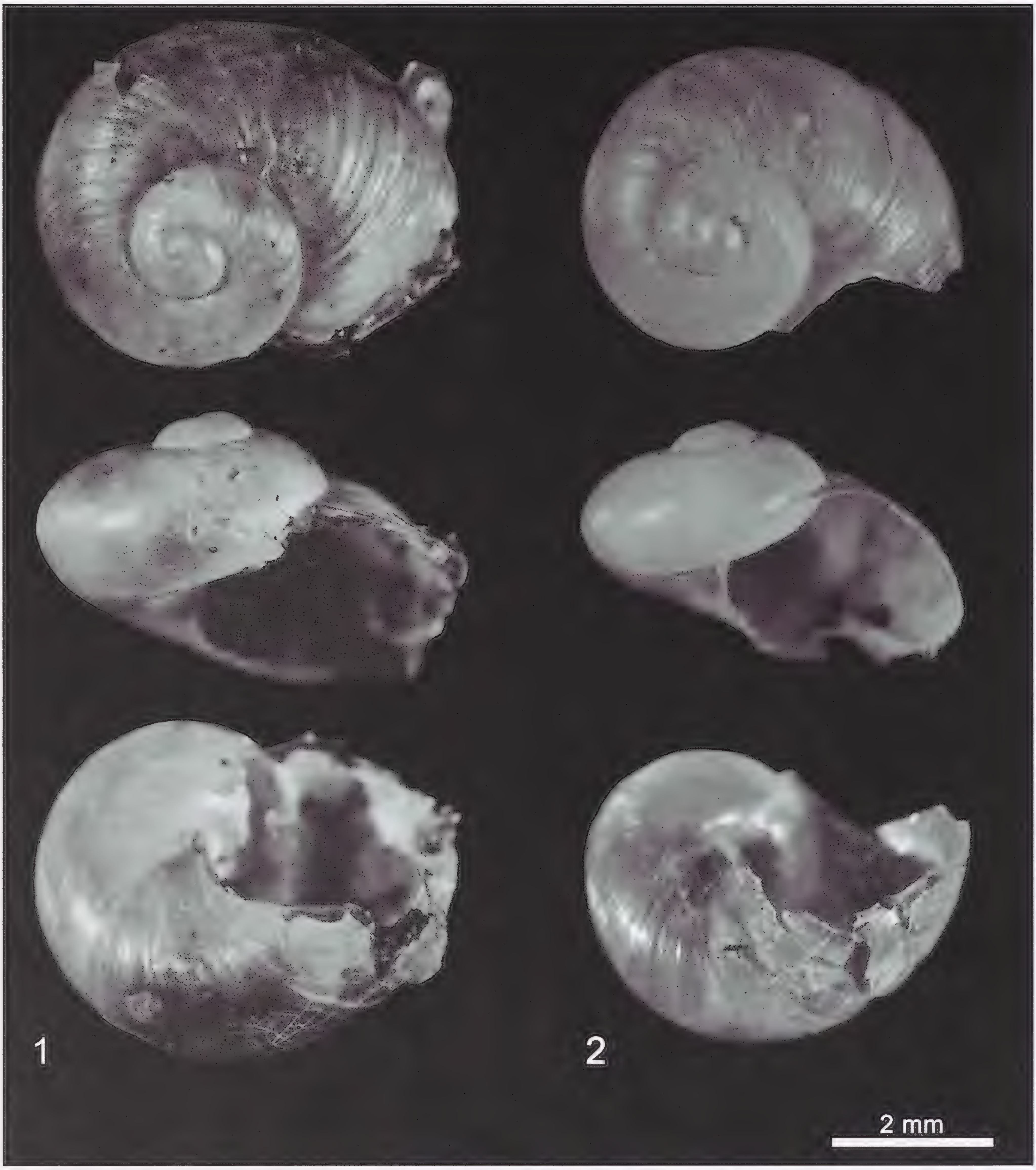
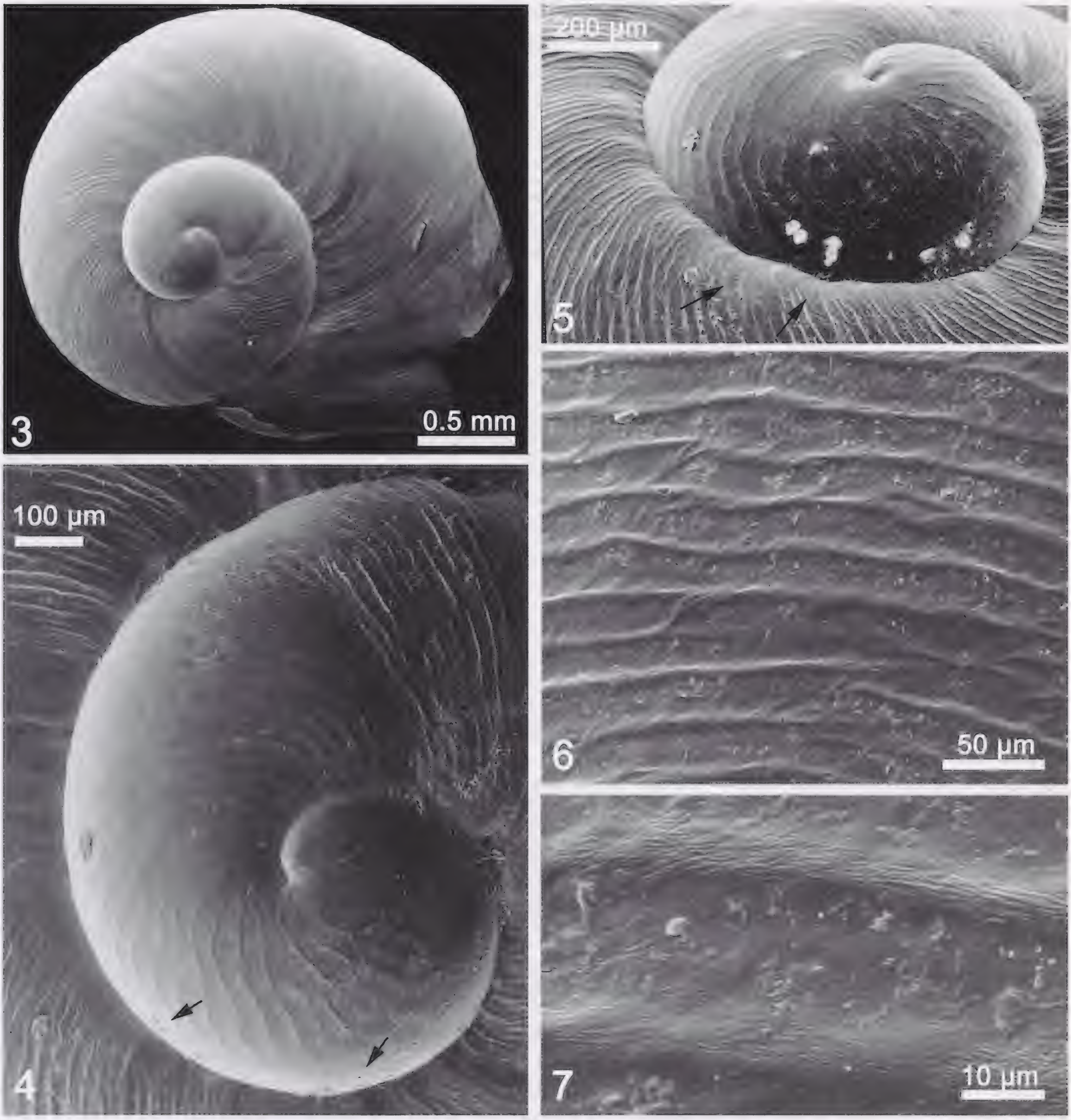
[1] Dipartimento di Scienze Ambientali, Università di Siena, Via Mattioli 4, 53100 Siena, Italy



Figs 1-2 Two shells of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, F. Giusti leg. 14.09.1981.

in M. Madonie" which according to him matched *V. paulucciae* except for a few minor differences. Westerlund also wrote that he agreed with authors, such as L. Benoit, that the true *V. musignani* was a synonym of *O. annularis*. Pirajno's species, was then ignored, which is presumably why Alzona (1971) regarded it as a doubtful species.

As far as we know no syntype exists. Giannuzzi-Savelli *et al*. (1986), who revised what remains of the malacological collection of E. Pirajno, baron of Mandralisca (kept in the Fondazione Mandralisca at Cefalù), found no material of *V. musignani* and concluded that the type material was lost. We tried to trace possible syntypes in the collections of malacologists who could have been in contact with Pirajno (the Monterosato collection



Figs 3-7 Detail of shell microsculpture of specimens of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, G.B. Osella leg. 24.10.1981. A whole shell (Fig. 3), details of protoconch (Figs 4-5) and teleoconch (Figs 6-7). Note some pits on protoconch near suture (Fig. 4, arrows) (Fig. 4) and fine longitudinal periostracal crests on protoconch (Fig. 4, between the two arrows) and on first whorls of teleoconch (Fig. 5, arrows).

at the Museo Civico di Zoologia, Rome, Italy; the Paulucci collection at the Museo di Storia Naturale dell'Università di Firenze, Florence, Italy), but without success.

The only historical material we found consists of four shells belonging to *Vitrina pellucida* (Müller, 1774), labelled "*V. musignani* Pir., Sicilia, Mte Madonie", kept in the Westerlund collection at the Naturhistoriska Museet (Göteborg, Sweden). These shells are probably those Westerlund (1886) received from Sicily under the name *V. musignani* and considered to belong to *V. paulucciae* (the fact that these shells belong to a species different from *V. paulucciae* may explain the "minor differences" Westerlund noted with respect to *V. paulucciae*).

The original description (*V*[*itrina*]. testa subglobosa, tenuissima, pellucida, hyalina, longitudinaliter tenui et eleganter striata; anfractibus tribus, ultimo majore, subcarinato; apertura rotundata, spira exertiuscula), the dimensions (shell diameter: 2 Sicilian lines, i.e. about 3.6 mm), and the remarks ("questa vitrina è la più piccola di quelle sin ora conosciute" [this vitrina is the smallest of all those known up to now]) are compatible with our material from Monte Soro and with the syntypes of *V. paulucciae.* Only one character is apparently in contrast, i.e. "longitudinaliter striata", but Pirajno probably used this expression to describe the fine radial ribs of the teleoconch as being parallel to the shell vertical axis and hence, "longitudinal".

The only illustration of this nominal species, that of Benoit (1857-62, Pl. 1, fig. 4), is extremely similar to our shells from Monte Soro and the syntypes of *V. paulucciae.* It has evident radial ribs which Benoit (1857-62, p. 60) describes with the expression: "striis subtilissimis longitudinalibus eleganter ornata". In order to define this nominal taxon objectively, the shell reported in Fig. 1 is designated as the neotype of *V. musignani.* As for *V. paulucciae*, we regarded it as a junior synonym of *V. musignani.* We feel authorized to propose synonymy even in the absence of an anatomical study of topotypical material of *V. paulucciae*, because it perfectly agrees with *V. musignani* in all shell characters.

The present paper is devoted only to the redescription of *V. musignani.* A special paper on *V. polloneriana* is in preparation since its relationships and supraspecific allocation were more complex and required the revision of other plutoniine vitrinids.

MATERIAL AND METHODS

Shells were photographed under the light microscope (Wild M5A). All dimensional parameters (shell height, shell diameter, aperture height and aperture diameter) were measured using calipers. Living specimens were drowned in water, then fixed and preserved in 75% ethanol buffered with $NaHCO_3$. The bodies were isolated after crushing the shells and dissected under the light microscope (Wild M5A) using very thin pointed watchmaker's tweezers. Anatomical details were drawn using a Wild camera lucida. Radulae were extracted manually from the buccal bulbs, washed in pure 75% ethanol, mounted on copper blocks with electronconductive glue, sputter-coated with gold, and photographed using a Philips 505 SEM.

The material examined is listed as follows: locality, municipality and province names in parenthesis, UTM reference, collector(s), date, number of specimens in parenthesis. Unless otherwise indicated, all the specimens illustrated are kept in the Giusti Collection (Dipartimento di Biologia Evolutiva, Via Mattioli 4, 53100 Siena, Italy).

Key to acronyms used in Figs 9-14, 23-25: A, atrium; AG, albumen gland; AP, atrial pleats; APP, accessory penial pilaster; BC, bursa copulatrix; BW, body wall; DV distal vagina; EGL, external glandular layer; FHD, first hermaphrodite duct; FO free oviduct; GA, glandula amatoria; GR, glandular roll; IGL, internal glandular layer; LDBL, left-dorsal body lobe; LVP, larger vaginal pilaster; PC, penial complex; PG penial gland; PGA, papilla of glandula amatoria; POS, prostatic portion of ovispermiduct; PR, penial retractor muscle; RBL, right body lobe; SVP, smaller vaginal pilaster; T, talon; UOS, uterine portion of ovispermiduct, VD, vas deferens; VDO, vas deferens opening; VW vaginal walls.

REDESCRIPTION OF *VITRINA MUSIGNANI*

Oligolimax musignani (Pirajno, 1842)

Vitrina Musignani Pirajno, 1842: 157-158.

Type material original type material lost (Giannuzzi-Savelli *et al.*, 1986). The specimen illustred in Fig. 1 is designated as neotype. The neotype is deposited in the Museo Zoologico de "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze, MZUF 21832.

Type locality "... nelle alture delle Caronie, nell'ex feudo di Levanche, sotto il fogliame caduto in parti umide" [on the Caronie mountains, in the ex-feud named Levanche, under litter in damp sites]. Following the neotype designation, the type locality becomes: Monti Nebrodi [Caronie mountains], Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398.

Vitrina (Oligolimax) paulucciae Fischer in Paulucci, 1878: 1, 23-24.

Type material seven syntypes are in the Paulucci collection, Museo Zoologico de "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze (6 sh, MZUF 10567; 1 sh MZUF 10568).

Type locality "in Aspromonte Calabriae" (more details on the original label: Regione Cavaliere under the bark of beech-trees, at 1700 m of altitude).

Historical material examined **Calabria** "Aspromonte, Regione Cavaliere, m 1700, sotto la corteccia dei faggi", C. Caroti leg. 1877 (7 syntypes of *Vitrina paulucciae*, Paulucci collection; they consist of six badly preserved, partly broken shells at various stages of growth, glued on a label [MZUF 10567] and one badly preserved shell [MZUF 10568]). **Sicily** "Sicilia" (1 sh det. *Vitrina pellucida*, Caramagna collection, MZUF 17995).

Recent material examined **Sicily** Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, F. Giusti leg. 14.9.1981 (1 shell, designated as neotype of *V. musignani*; MZUF 21832), F. Giusti leg. 14.9.1981 (3 spirit specimens), G.B. Osella leg. 24.10.1981 (1 spirit specimen).

Diagnosis the smallest species of *Oligolimax* characterized by protoconch with few pits near suture of first half whorl and fine, wavy, radial, rather widely and regularly spaced, irregularly branched periostracal crests; teleoconch with fine, radial, closely and regularly spaced ribs; genitalia with large, wide glandula amatoria almost entirely covered by thick glandular layer.

Description Shell (Figs 1-7) dextral, very small, depressed conical, rather globose, very thin and fragile, translucent, silky, shiny and yellowish when fresh; spire consisting of $2^2/_3 - 3^1/_3$, rather rapidly growing whorls; last whorl large, dilated, slightly descending, sometimes slightly angled at periphery; sutures rather superficial, slightly wavy (due to ribs); surface of protoconch (about $1^1/_8$ whorls) with very few pits near suture (presence of pits confirmed on decorticated protoconchs) and fine, wavy, radial, rather widely and regularly spaced, irregularly branched periostracal crests and very fine longitudinal periostracal crests, particularly on marginal side; surface of teleoconch on upper side of shell with fine, radial, closely and regularly spaced, slightly wavy ribs

TABLE 1
Shell dimensions of *Oligolimax musignani.*

	shell height	shell diameter	aperture diameter	number of whorls	N
Sicilia, Caronie, nell'ex feudo di Levanche (Pirajno, 1842)	about 1.8 mm [1 Sicilian line]	about 3.6 mm [2 Sicilian lines]		3	
Sicilia, Monte Soro	2.1 - 2.3 mm	3.2 - 3.6 mm	1.9 – 2.1 mm	$2\,^{2}/_{3}$ - $2\,^{5}/_{6}$	2
Sicilia (MZUF 17995)	2.6 mm	about 3.8 mm	about 2.0 mm	$2\,^{11}/_{12}$	1
Calabria, Aspromonte (Fischer in Paulucci, 1878)	2.3 mm	3.5 mm	2.0 mm	$3\,^{1}/_{3}$	

(substituting crests on protoconch), each with thin, short branches, those of one rib contacting following rib; ribs less evident near sutures, on final part of last whorl and on lower side of shell, especially around umbilicus; aperture wide (diameter more than half that of shell), oblique, oval; peristome incomplete, simple, with vertical columellar margin bordered by thin periostracal fringe (aperture membrane) and upper and lower peristomal vertices joined by very thin whitish parietal callosity; umbilicus very small, slit-like, partly covered by periostracal fringe bordering peristome. Shell dimensions, see Tab. 1.

Animal and anatomical characters (Figs 8-9) body withdraws more or less entirely into shell; body brownish-black, mantle with brownish-black spots, border and lobes of mantle and lateral parts of sole weakly pigmented; mantle border without shell lobes, rather angled at right upper vertex and with left-dorsal and right body lobes; left-dorsal body lobe forming sort of calotte over neck and narrow process above pneumostome; right body lobe triangular, its smaller side bordering lower side of pneumostome; foot aulacopod with tripartite sole; central part tapering and ending before posterior tip of foot; lateral parts of sole fusing at posterior tip of foot; posterior tip of foot sharply pointed, without caudal apparatus; sygmurethrous kidney; jaw oxygnathous (Fig. 8); right ommatophore retractor free of penis and vagina, running left of penis and below penial retractor; pedal penial innervation (for other details on animal, see Fischer in Paulucci, 1878: 23-24).

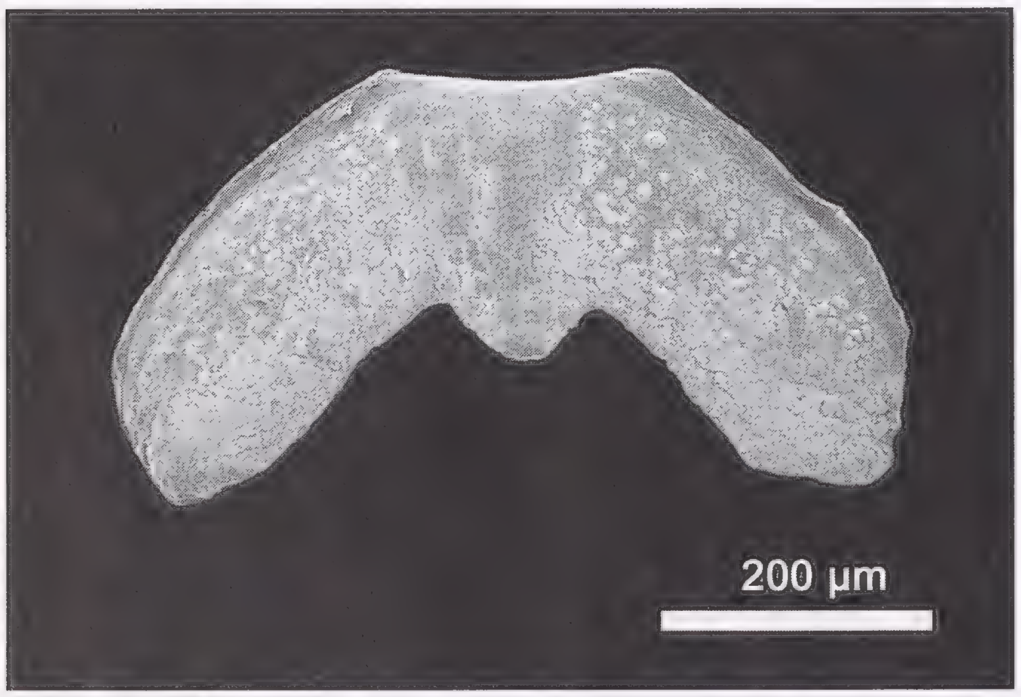
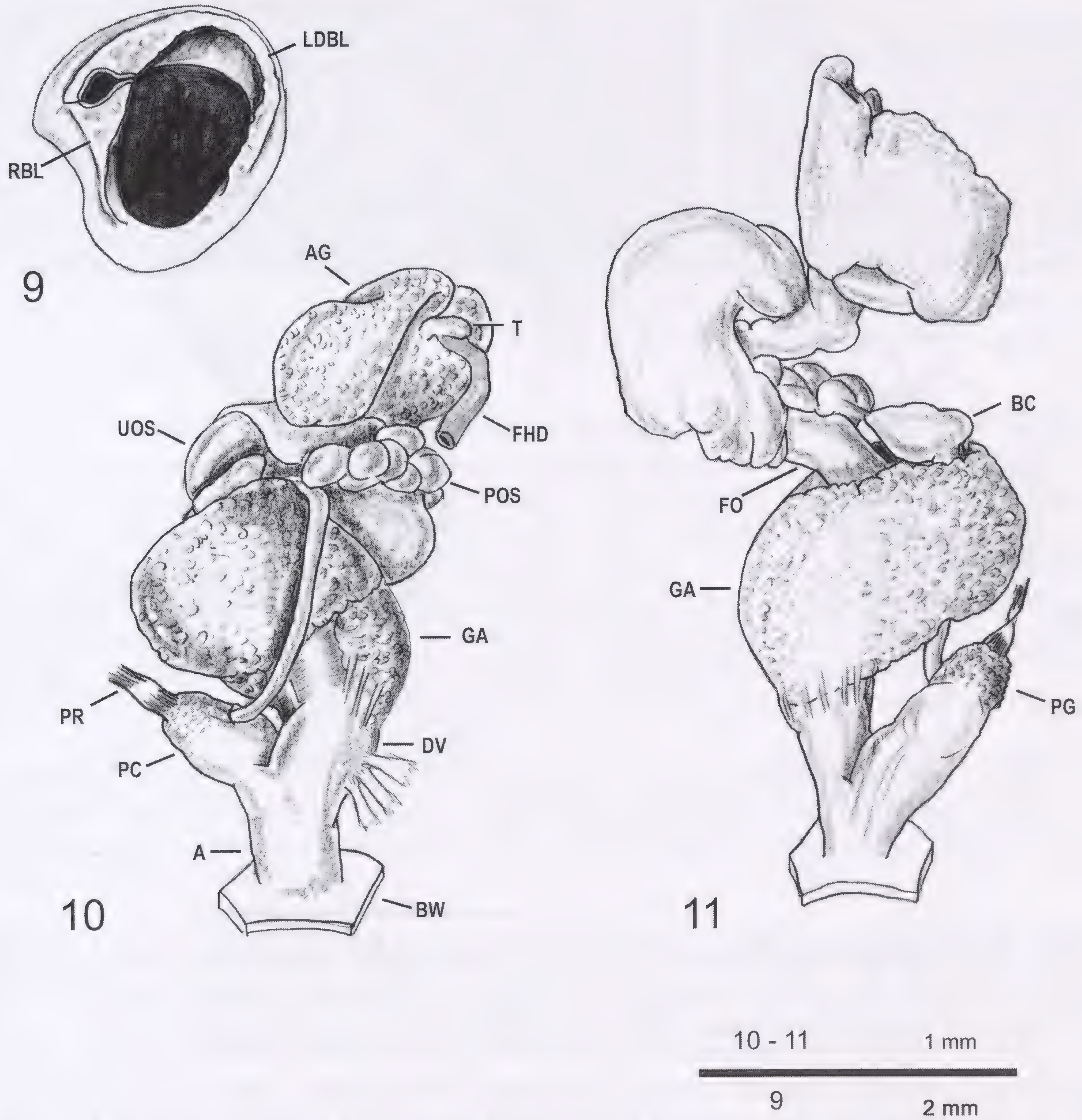


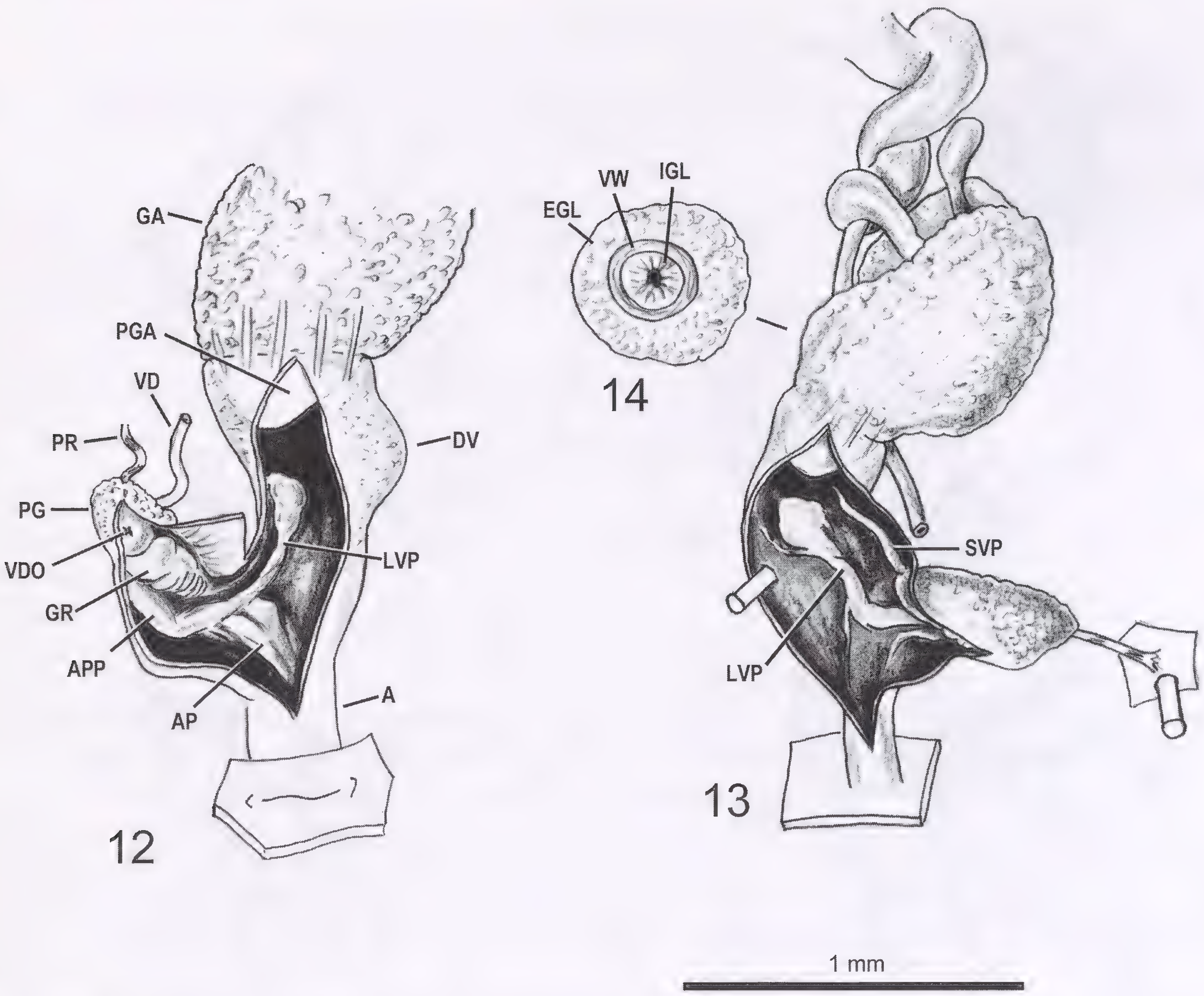
Fig. 8 The jaw of a specimen of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, F. Giusti leg. 14.09.1981.

Genitalia (3 specimens examined) (Figs 10-14) first hermaphrodite duct blackish, ending in base of small, sac-like talon; albumen gland large, square, bilobate; ovispermiduct tightly coiled on itself, its uterine portion ending distally in free oviduct. Bursa copulatrix small with duct very short; duct of bursa copulatrix and distal part of free oviduct concealed by external glandular layer of glandula



Figs 9-11 Mantle edge and body lobes (Fig. 9) and distal genitalia (Figs 10-11) of a specimen of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, G.B. Osella leg. 24.10.1981.

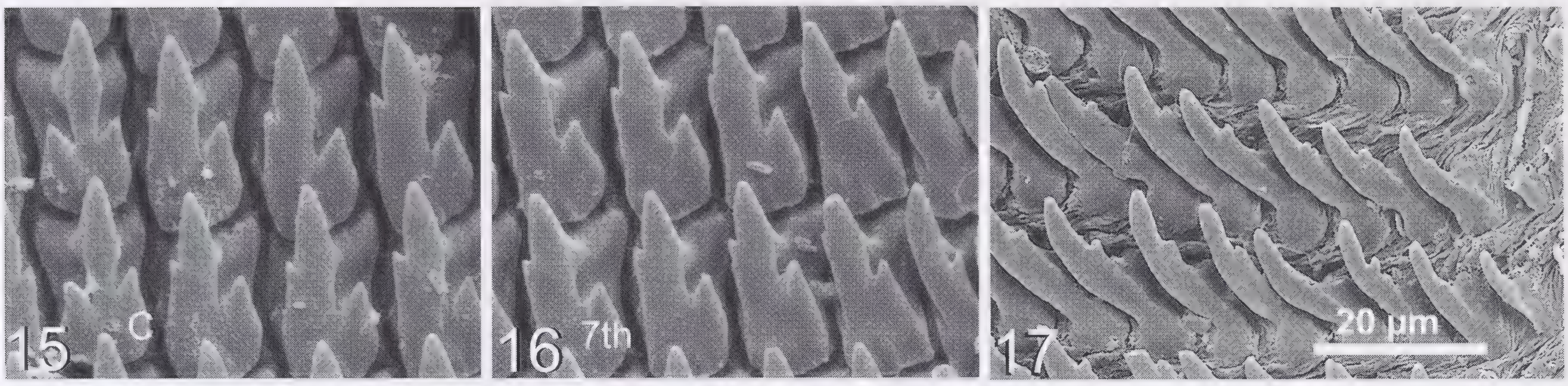
amatoria. Proximal vagina modified into sort of stimulatory portion or glandula amatoria rather short and wide, cylindrical, with rather thin muscular walls, almost completely wrapped by very thick glandular layer externally and lined internally by another rather thick glandular layer delimiting narrow lumen; distal part of glandula amatoria containing rather large conical papilla open at tip, which protrudes into distal vagina (papilla consisting of superimposition by invagination of final part of proximal vagina into initial part of distal vagina, so its double walls lie one over the other, connected by thin strips of tissue). Distal vagina with very thin, subtransparent walls with sparse traces of glandular tissue and internally with two longitudinal pleats. Larger vaginal pleat, that which originates from rather large knob (this knob, variable in shape, is situated on vagina wall near tip of papilla of glandula amatoria), rather thick, sometimes flanked by very thin pleats, and distally branched into two, one branch continuing inside penis, other inside the genital atrium where it remains single or gives rise to system of smaller pleats. Smaller vaginal pleat very slender and distally fused with distal portion of penial glandular roll (see below). Penial complex short, club-like,



Figs 12-14 Distal genitalia and internal structure of penis and vagina (Fig. 12-13) and section of glandula amatoria (Fig. 14) of a specimen of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, F. Giusti leg. 14.09.1981.

without penial sheath ("penial tunica", Hausdorf, 1995), with apex and one side (that usually facing distal vagina) covered by layer of glandular tissue ("glandula penis" or "apical gland", Hausdorf, 1995). Inside penial complex there are two structures: one larger ("Drüsenwülste des Penis", Forcart, 1959) than the other. Glandular roll situated in correspondence of external penial gland and filling most of penis lumen, divided into two portions: proximal, consisting of yellow knoll, at apex of which vas deferens opens, and distal, pale yellow in colour, with irregular contour and some evidence of transverse furrows (small dimensions prevent recognition of correspondence with lamellate portion of glandular rolls in other vitrinids). Non glandular pleat (impossible to ascertain homology with so-called secondary or accessory pilasters inside penis of other vitrinids), slender, arising from one side of glandular roll and extending forward to end level with where penis enters genital atrium by fusing on one side with pleat or system of pleats which run on genital atrium wall, and on other side with larger vaginal pleat (the latter and penial pleat form one continuous structure). Vas deferens rather short and wide, entering penis laterally at about half penis length, turning towards penis apex just inside penis (level with basal portion of glandular roll) to open at tip of proximal portion of glandular roll. Penial retractor muscle inserted on penis apically/subapically, passing above right ommatophore retractor and ending on diaphragm.

Radula (2 specimens examined) (Figs 15-17) consisting of many rows, each of 49-55 teeth, according to formula 1-2/1 + 13-14/2-5 + 10-11/3 + C/3 + 10-11/3 + 13-14/2-



Figs 15-17 The radula of a specimen of *Oligolimax musignani* (Pirajno, 1842) from Monti Nebrodi, Monte Soro, 1847 m (Cesarò, Messina), 33SVB7398, F. Giusti leg. 14.09.1981. Key: C, central tooth; 7th, seventh tooth.

5 + 1-2/1. Central teeth with robust plate having pointed upper vertices and crown tricuspid consisting of long mesocone and very short and pointed ectocones. Lateral teeth with robust basal plate having outer pointed upper vertex and crown tricuspid consisting of very large mesocone, small endocone (at 2/3 of mesocone length) and very small pointed ectocone. Marginal teeth after tenth - eleventh lateral teeth with basal plate having crown bicuspid consisting of progressively slenderer and inwardly curved mesocone and very small ectocone at half mesocone length. Last marginal teeth have ectocone split into two or more (3-5) small points (in this case outer side of mesocone jagged). Extreme marginal teeth very reduced with crown monocuspid and thorn like.

Etymology these two vitrinid nominal species were dedicated to two famous Italian naturalists, the former to Carlo Luciano Bonaparte (1803-1857), prince of Canino and Musignano, the latter to the marchioness Marianna Panciatichi Ximenes d'Aragona Paulucci (1835-1919).

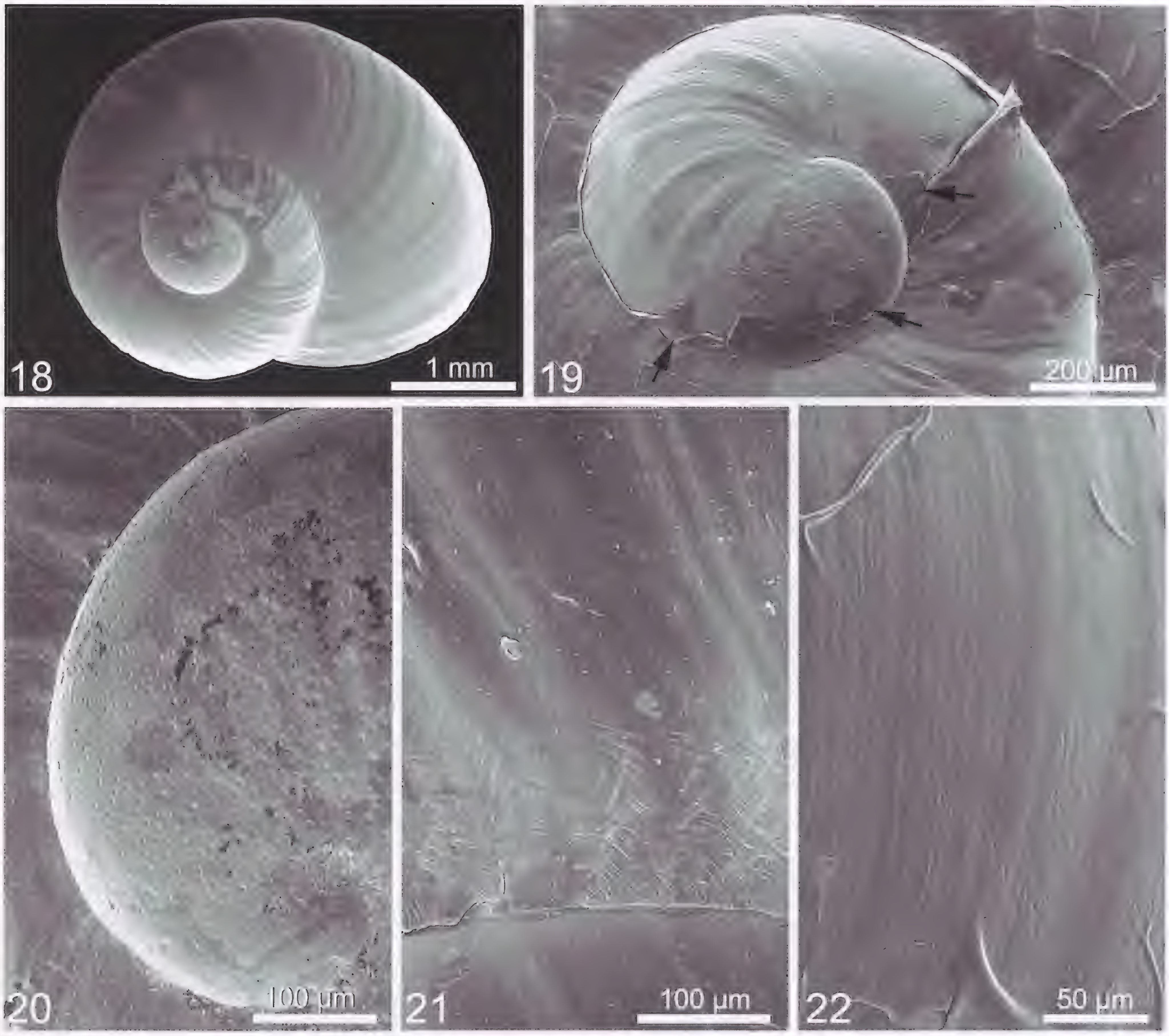
Habitat *Oligolimax musignani* has only been found in beech woods up to 1847 m of altitude.

Geographical distribution endemic to southern Calabria and northeastern Sicily.

DISCUSSION

Vitrina musignani shares characters with the species usually included in *Oligolimax* (formerly *Gallandia*), the latter sometimes considered a distinct genus, sometimes a subgenus of *Phenacolimax*. These characters are: mantle border without shell lobes; right ommatophore retractor free of penis and vagina, running left of penis and below penial retractor; glandula amatoria rather short and wide, containing conical papilla perforated and open at tip; distal vagina with two internal longitudinal pleats and one knob situated near tip of papilla of glandula amatoria; penial complex short and club-like, without penial sheath and with penial retractor muscle inserted apically/subapically and passing above right ommatophore retractor before ending on diaphragm; apex and one side (that facing vagina) of penial complex with penial gland; large glandular roll (in correspondence with external penial gland) and slender penial pleat inside penis; vas deferens entering penis laterally, and turning towards penis apex just inside penis to open in small pore at tip of proximal portion of glandular roll. This is why we (Manganelli *et al.*, 1995) proposed *Gallandia* as a junior synonym of *Oligolimax* (*V. musignani* is senior synonym of *Vitrina pauluccia e*, the type species of *Oligolimax*).

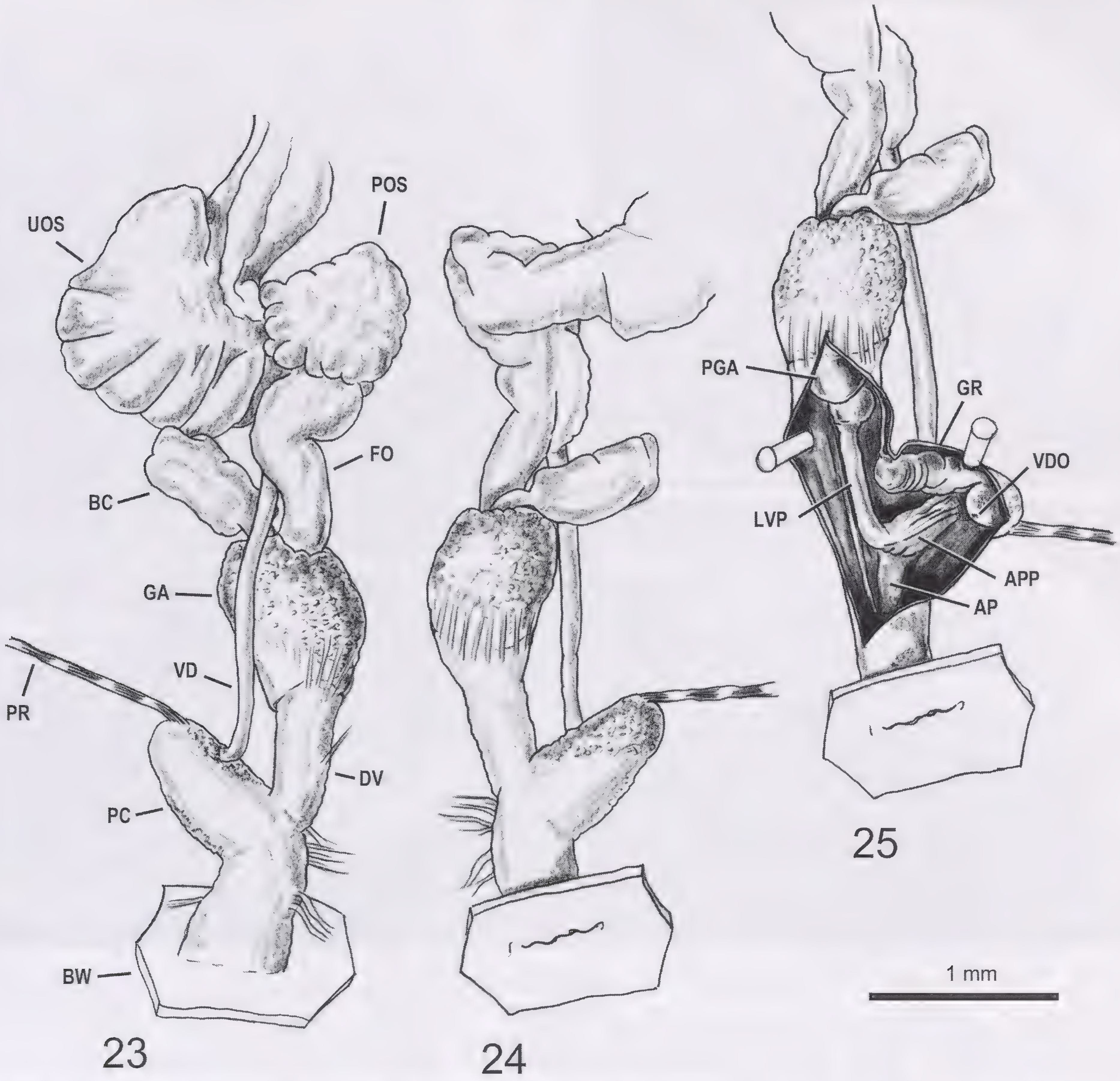
Besides *V. musignani*, *Oligolimax* includes *O. annularis* (Studer, 1820) and *O. olympicus*



Figs 18-22 Detail of shell microsculpture of specimens of *Oligolimax annularis* (Studer, 1820) from Monte Pollino, Serra Dolcedorme (Castrovillari Cosenza), 33SXE01, C. Caroti leg. (Figs 18, 20-21) and Monte Terminillo (Micigliano, Rieti), 33TUH3504, F. Giusti leg. 8.8.1966 (Figs 19, 21). A whole shell (Fig. 18), details of protoconch (Figs 19-20) and teleoconch (Figs 21-22). Note pits on decorticated and non decorticated areas (arrow) of protoconch (Fig. 19, arrows).

(Hausdorf, 1995). *O. musignani* differs from *O. annularis* in that surface of protoconch has fine, wavy, radial, periostracal crests and a few pits near suture (protoconch with no crests but with rare and irregularly spaced growth ribs and longitudinal rows of pits in *O. annularis*); surface of teleoconch (on upper side of shell) with fine, radial, closely and regularly spaced ribs (rather smooth, with traces of ribbing and more evident, irregularly spaced growth lines in *O. annularis*); larger glandula amatoria, due to thicker external glandular layer which almost entirely wraps vagina walls (glandula amatoria rather small, with thin external glandular layer only partly enveloping vagina wall in *O. annularis*). With regard to the insertion of the penial retractor, there is no substantial difference between the two species. The apical insertion described by Hausdorf (1995: p. 67) in *O. annularis*, is not constant. Italian specimens of *O. annularis* have penial retractor inserted slightly subapically, exactly as in *O. musignani* (for shell and anatomy of *O. annularis*, see Figs 18-25).

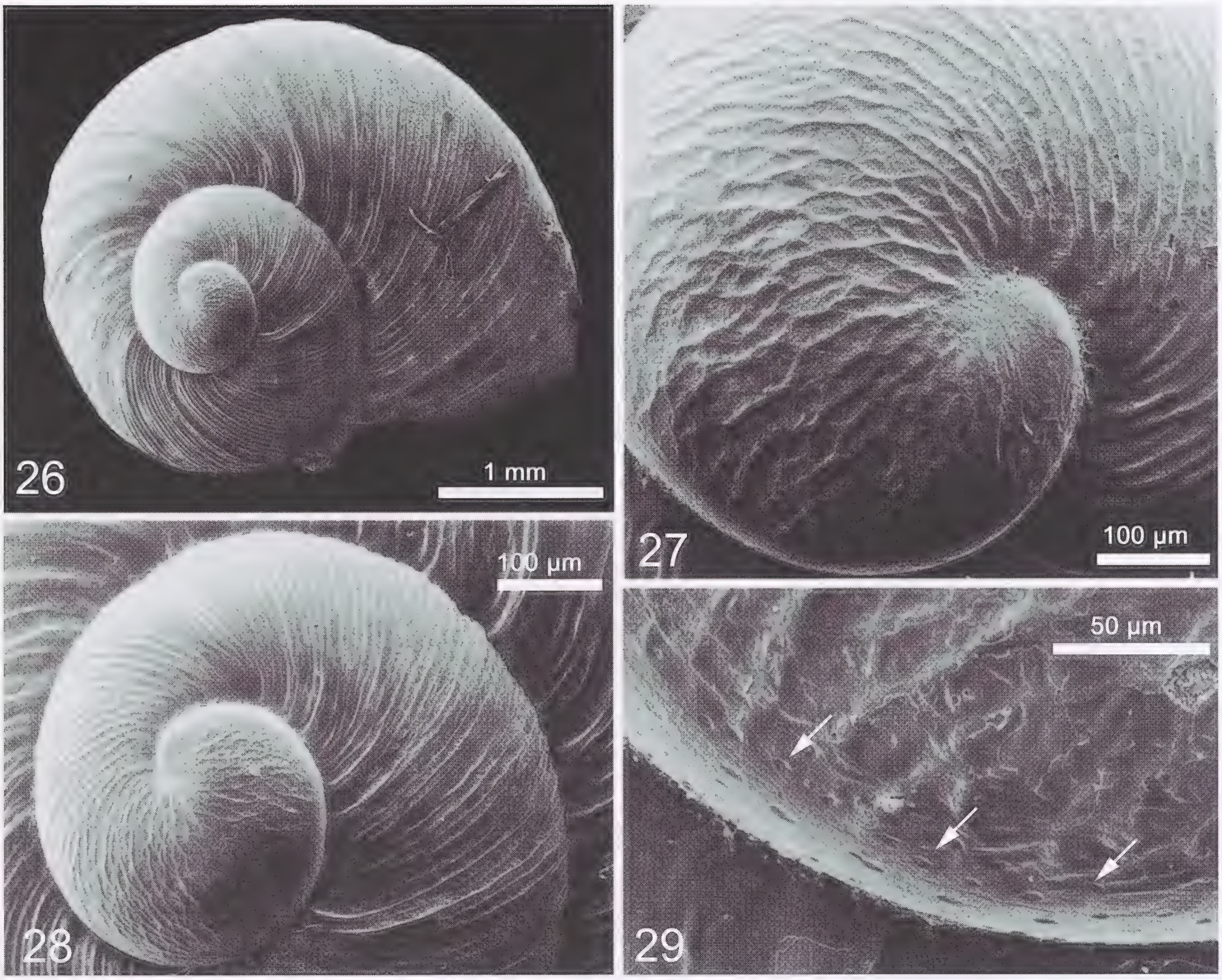
O. musignani differs from *O. olympicus* by: shell more depressed conical (shell more conical and with more pointed apex in *O. olympicus*); surface of protoconch with few pits



Figs 23-25 Distal genitalia (Figs 23-24) and internal structure of penial compex and vagina (Fig. 25) of a specimen of *Oligolimax annularis* (Studer, 1820) from Monte Pollino, Colle del Dragone (Morano Calabro, Cosenza), 33SWE9517, F. Giusti leg. 13.10.1977.

near suture of first half whorl and fine, wavy, radial, rather widely and regularly spaced, irregularly branched periostracal crests (surface of intact protoconch with some rows of pits only near suture of first half whorl and very close fine, wavy, radial crests, imparting reticulate appearence in *O. olympicus*); vagina short and wide (long and slender in *O. olympicus*); glandula amatoria wide and almost entirely covered by thick glandular layer (glandula amatoria with external glandular layer limited to proximal portion or absent in *O. olympicus*); papilla of glandula amatoria well developed and bulging well into distal vagina (papilla of glandula amatoria reduced in *O. olympicus*); penial retractor slightly subapical (more evidently subapical in *O. olympicus*) (for shell and anatomy of *O. olympicus*, see Figs 26-29 and Hausdorf, 1995: p. 69, Fig. 9).

In addition to these species, a number of nominal taxa has been assigned to *Oligolimax* (or to its junior synonym *Gallandia*): *Helicarion sieversi* Mousson, 1876, *Vitrina subconica* Boettger, 1878, *Lampadia lederi* Boettger, 1878, *Vitrina (Trochovitrina) subcarinata* Boettger, 1880, *Vitrina (Oligolimax) annularis* forma *caucasica* Westerlund, 1886, *Vitrina (Oligolimax) annularis* var. *persica* Boettger, 1889 *Vitrina (Oligolimax) raddei* Boettger, 1889, *Vitrina tripolitana* Sturany, 1909, *Phenacolimax (Oligolimax) sturanyi sturanyi* Forcart, 1959,



Figs 26-29 Detail of shell microsculpture of a specimens of *Oligolimax olympicus* (Hausdorf, 1995) from Orhangazi, 35TPE98, B. Hausdorf leg. 25.09.1987. Note pits (arrows) near sutures of first whorl. A whole shell (Fig. 26) and details of protoconch (Figs 27-29). Note numerous pits on protoconch near suture (Fig. 29, arrows).

Phenacolimax (Oligolimax) sturanyi brandti Forcart, 1959, and *Phenacolimax (Oligolimax) zilchi* Forcart, 1959 (Forcart, 1959; Zilch, 1984; Hausdorf, 1995).

Many of them, specifically *V. annularis* forma *caucasica*, *V. annularis* var. *persica*, *V. raddei*, *H. sieversi*, *V. subcarinata*, *V. subconica* from the Caucasus and North Iraq, *V. tripolitana* and *P. sturanyi sturanyi* from Tripolitania (Libya), and *P. zilchi* from Cyrenaika (Libya), are not known anatomically and consequently no conclusion can be reached about their status and relationships.

L. lederi, from the Caucasus, was assigned to *Trochovitrina* (as subgenus of *Helicolimax*) by Boettger (1880). This taxon was considered a distinct genus by Schileyko (1986) (*Trochovitrina* is characterized by: free oviduct very short, absence of bursa copulatrix and its duct, peculiar structure of wall of glandula amatoria, absence of papilla of glandula amatoria, penis with small subapical tubercle; Schileyko, 1986: pp. 130-131, Fig. 4). In a revision of Turkish vitrinids, Hausdorf (1995) did cladistic analysis to elucidate the relationships of *T. lederi* with *Gallandia annularis* and *G. paulucciae* using *Insulivitrina* as outgroup. He found that these three taxa constitute a monophyletic group (*G. annularis* (*G. olympica*, *L. lederi*)) and consequently regarded *Trochovitrina* as a junior synonym of *Gallandia* (in turn a junior synonym of *Oligolimax*). However, before synonymizing *Trochovitrina* with *Gallandia*, it would have been opportune to carry out anatomical re-examination of this peculiar species and analysis of its relationships within a larger group of taxa.

On the contrary, what is known of the anatomy of *P. sturanyi brandti* (Forcart, 1959: pp. 3-4, Fig. 1, Pl. 1, fig. 3) supports inclusion in *Oligolimax*. *P. sturanyi brandti* is very similar to *O. annularis* and *O. musignani*. It differs from *O. musignani* by: shell markedly depressed, last whorl very dilated, penis longer, penial retractor inserted subapically and bursa copulatrix with very long duct.

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MORPHOLOGICAL AND ECOLOGICAL FEATURES OF *THEODOXUS FLUVIATILIS* (LINNAEUS, 1758) FROM BALTIC BRACKISH WATER AND GERMAN FRESHWATER POPULATIONS

M.L. ZETTLER[1]*, J. FRANKOWSKI[1], R. BOCHERT[1], M. RÖHNER[1]

Abstract *In an investigation of the differences and similarities within the species* Theodoxus fluviatilis, *we analysed 11 brackish water populations from the Baltic Sea and 8 freshwater populations from northern Germany.* T. fluviatilis *from the two habitats are primarily distinguished by different habitat preferences. We have never observed the migration or colonization of rivers by brackish water animals or vice versa. While mostly stones and wood serve as typical substrata in freshwater, we found both stones and plants (*Fucus, Potamogeton, Zostera*) as habitats in brackish water environments. In an analysis of morphology (shell size, operculum, radula), we found no significant differences between brackish and freshwater populations of* T. fluviatilis *in the Baltic Sea area. The variability of shell morphology and ecological behaviour of* T. fluviatilis *within and/or between brackish and freshwater populations is most likely based on different habitat conditions and demonstrates the large phenotypic plasticity of the species.*

Key words Theodoxus fluviatilis, *Baltic Sea, ecology, morphology, operculum, radula, brackish water, freshwater.*

INTRODUCTION

Since Linnaeus decribed two different species for the Baltic area in 1758, *Nerita fluviatilis* from freshwater and *N. littoralis* from brackish waters, opinions differ as to whether these are different species, subspecies, forms, varieties or adaptations. In recent decades the scientific opinion has concluded that these are simply two different forms of one species, namely *Theodoxus fluviatilis* (Linnaeus, 1758).

The freshwater form (*Theodoxus fluviatilis fluviatilis*) is very common in central Europe. Its range extends from Western Russia to Iberia and from southern Scandinavia to the Balkan peninsula. *T. fluviatilis* is more common in central-eastern Europe (Glöer, 2002). If we restrict our area of focus to the Baltic Sea, the freshwater *Theodoxus* is common in all continental Baltic states (Russia, Estonia, Lithuania, Latvia, Poland, Germany, Denmark). In Scandinavia (Norway, Sweden) and Finland freshwater populations are missing or are very sparse. Only the southern provinces of Sweden and the vicinity of Stockholm belong to the distribution area (Hubendick, 1944; 1947; Nyman & Skoog, 1977; von Proschwitz, 2001). In Finland, isolated freshwater populations are known only from the Åland islands (Segerstråle, 1945; Carlsson, 2000). From freshwaters in Norway *T. fluviatilis* was erroneously mentioned (see Økland 1990, p 165).

The brackish water form (*Theodoxus fluviatilis littoralis*) is found in moderate saline areas of the North Sea and Baltic Sea. In the North Sea we know it from the Scottish Orkneys (Boycott, 1936; Nicol, 1938) and from brackish habitats in Denmark (Fretter & Graham, 1978). It lives all over the Baltic Sea with concentrations in the less brackish areas of inner coastal waters in the southern part and in regions of decreasing salinities off the coast of the northern part (Fig. 1). The salinity varies from 2-3 psu in the inner parts of the large gulfs, to 6-8 psu in the Baltic proper, to 20-24 psu in the Kattegat. Given an available substratum, *Theodoxus* is able to colonize zones between coastal and offshore waters to a depth of 60 m (e.g. Wlodarska-Kowalczuk & Janas, 1996). In the more saline areas of the southern Baltic, *Theodoxus* is restricted to inner coastal waters like

1 Baltic Sea Research Institute Warnemuende, Seestrasse 15, D-18119 Rostock, Germany;
*Tel: +49(0)381 5197 236; michael.zettler@io-warnemuende.de

Bodden and Haffe. The salinity varies between 2 and 15 psu. From the Belt Sea (South) to the Baltic Proper (North) the salinity decreases within the Baltic. Below 7-8 psu we also find populations in off-shore waters. In the Arkona Basin we observed specimens on stones and boulders up to depths of 23 m. In Poland (Gdansk Basin) the species was observed at a depth of 60 m (Wlodarska-Kowalczuk & Janas, 1996).

Some important *Theodoxus* localities surrounding the Baltic are: Schlei estuary, Darss-Zingst Bodden Chain and Greifswalder Bodden in Germany; Puck Bay and Wisla lagoon in Poland; Curonian lagoon in Lithuania; Riga Bay in Latvia; Väinameri and the Gulf of Finland in Estonia; certainly all the way from Tvärminne, across the Archipelago Sea to the Åland Islands and along the Swedish east coast up to the northern most parts

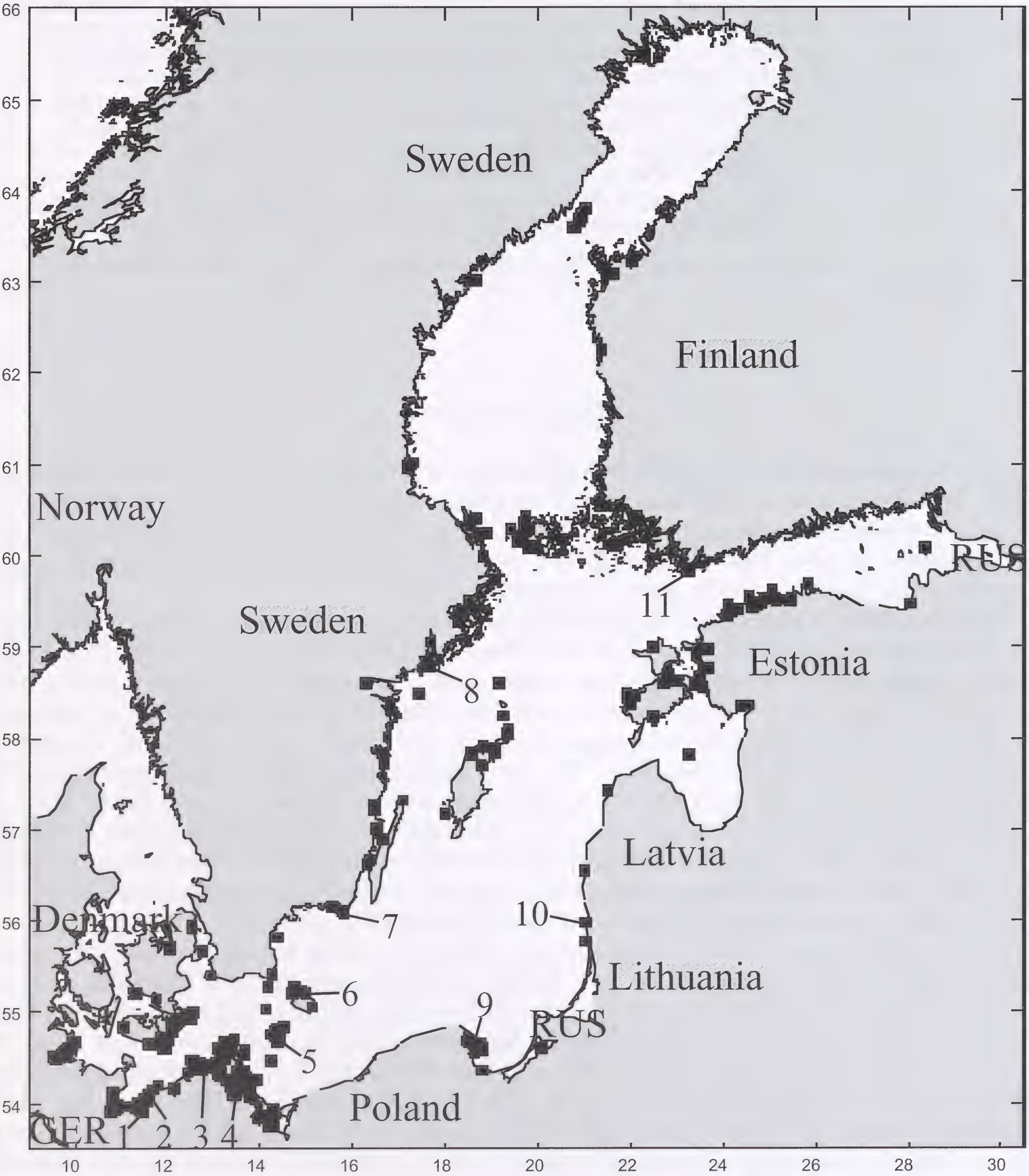

Figure 1 Distribution of *Theodoxus fluviatilis* within the Baltic Sea. The numbers indicate the sampling points of material which is included in this study and refer to table 1.

at Luleå; along the Finnish coast probably similarly distributed to the North; Bornhom and Roskilde Fjord in Denmark (see Figure 1). In Idefjorden (Skagerrak-Area), situated at the border between Norway and Sweden, an earlier record (19th century) of a brackish water population of *T. fluviatilis* exists (von Proschwitz, 2001). Due to heavy pollution during part of the 20th century it has probably died out there (Afzelius & Hardeng, 1995, von Proschwitz, 2001).

Apparently, it is extremely difficult to distinguish species of *Theodoxus* (Bandel, 2001). The main morphological features used for identification are size, colour patterns of the periostracum, the operculum and the radula, all of which are highly variable in this genus.

T. fluviatilis from brackish and freshwaters differ in the gross morphology of their shells. Specimens from freshwater on average become larger (Ulrich & Neumann, 1956; Kangas & Skoog, 1978) and have thicker shells than those from brackish water environments (Ulrich & Neumann, 1956). Some other differences between *Theodoxus* from brackish and freshwater habitats have been reported, including reproduction, behaviour, habitat demands and salinity tolerance (Bondesen, 1940; Neumann, 1960; Kangas & Skoog, 1978; Bandel, 2001; Glöer, 2002).

The aim of this study is to describe the ecological observations (salinity, substrata, abundance) and morphological features (shell size, operculum, radula) of brackish and freshwater populations of *Theodoxus fluviatilis*. Which differences could we find between these populations? Are there two different species in the Baltic Sea area, or merely one highly variable taxon?

MATERIAL AND METHODS

In order to assess the current distribution of *Theodoxus fluviatilis* in the Baltic Sea, the following papers were checked and analyzed in addition to our own observations:

Germany: For German Baltic waters several papers exist with information on *T. fluviatilis*. For more information of this area see the bibliography and database from Gerlach (2000) and Zettler *et al.* (in prep.). Some papers with important information on the distribution of *Theodoxus* are Krüger & Meyer (1937), Grahle (1932), Jaeckel (1940, 1952), Seifert (1938)

Poland: Falniowski *et al.* (1977), Falniowski (1989), Wlodarska-Kowalczuk & Janas (1996), Zmudzinski (1997), Haque et al. (1997), Kotwicki et al. (1999), J. Warzocha (pers. comm.)

Lithuania: D. Daunys (pers. comm.)

Latvia: Doss (1896), Knipowitsch (1909), Schlesch (1927, 1942)

Estonia: Knipowitsch (1909), Habermann (1935), Järvekülg (1979), Kotta & Kotta (1997)

Finland: Knipowitsch (1909), Segerstråle (1945), Boström & Bonsdorff (1997), Carlsson (2000)

Sweden: Knipowitsch (1909), Hubendick (1944, 1947), Skoog (1971), Kautsky *et al.* (1981, 1988), Kautsky (1989), Malm *et al.* (1999), von Proschwitz (2001)

Denmark: Schlesch (1934), Larsen (1936), Muus (1967), Rasmussen (1973)

[Norway: Afzelius & Hardeng (1995), von Proschwitz (2001), not included in Figure 1, because the Skagerrak and Kattegat were not taken into account in this paper]

Specimens were collected manually (handnet, diving) or by grabbing (Van Veen grab) at several brackish water and freshwater sites. Table 1 describes the assortment of the localities we used in this study. Shell length and shell height were measured using a stereo microscope (Stemi SV 11, CARL ZEISS, Germany). The indication of measurements are shown in Fig. 2. The dry weight of specimen was determined after

TABLE 1
Theodoxus fluviatilis material used in this study. The numbers of brackish water populations refer to Fig. 1. Besides we sampled and analysed some other populations (e.g. from Gotland and Öland)

site	country	year	Lat. [° N]	Long. [° E]	depth [m]	salinity [psu]	substrate
Baltic (1) -Poeldamm	Germany	2001	53.967	11.444	0.2 m	12.0	stones
Baltic (2) -Salzhaff	Germany	2002	54.064	11.599	0.3 m	11.0	stones
Baltic (3) -Barther Bodden	Germany	2002	54.414	12.769	0.4 m	8.3	plants
Baltic (4) -Greifswalder Bodden	Germany	2002	54.339	13.500	0.4 m	6.0	plants
Baltic (5) -Adlergrund	Germany	1999	54.459	14.232	12-23 m	7.4	stones
Baltic (6) -Bornholm	Denmark	2000	55.030	15.117	0.3 m	6.0 - 8.0	stones/ plants
Baltic (7) -Karlskrona	Sweden	2001	56.167	15.584	0.3 m	6.0 - 8.0	plants
Baltic (8) -Askö	Sweden	2002	58.483	17.420	0.2-5 m	6.0	stones/ plants
Baltic (9) -Puck Bay	Poland	1974	54.675	18.494	0.5 m	6.5 - 7.5	plants
Baltic (10) -Klaipeda	Lithuania	2002	55.975	21.034	14.1 m	7.0	stones
Baltic (11) -Tvärminne	Finnland	2003	59.833	23.201	0.5 m	5.0 - 6.0	plants
Lake-Großer Plöner See	Germany	2000	54.147	10.442	0.3 m	freshwater	stones
Lake-Mühlengeezer See	Germany	1997	53.762	12.060	0.3 m	freshwater	stones
Lake-Pinnower See	Germany	1997	53.608	11.540	0.3 m	freshwater	stones
Lake-Rudower See	Germany	1998	53.117	11.543	0.3 m	freshwater	stones
Lake-Schaalsee	Germany	1999	53.585	10.959	0.3 m	freshwater	stones
River-Alte Peene	Germany	1997	53.865	13.810	0.5 m	freshwater	plants
River-Bresenitz	Germany	2001	53.675	12.044	0.2 m	freshwater	stones
River-Randow	Germany	2002	53.615	14.103	0.5 m	freshwater	stones

drying in a heatchamber (60 °C, 24 h) and the shell weight after heating at 500 °C for 24 h (M 110, HERAEUS INSTRUMENTS, Germany) with laboratory balance (RC210P, SARTORIUS AG, Germany). The relationship between shell length and shell height and shell weight respectively were independently regressed. The software used was Excel. For the test of significance we calculated the confidence interval (95 %) for each regression. For a comparison of the different populations we analysed the radula from one specimen of each site. Three measurements of the central and two of the large intermediary teeth were taken (Fig. 2). Three different ratios were calculated (see Figure 2). The pictures were made by digital cam NIKON Coolpix 995 and by using REM (Cam Scan 44WEX).

RESULTS

ECOLOGICAL OBSERVATIONS

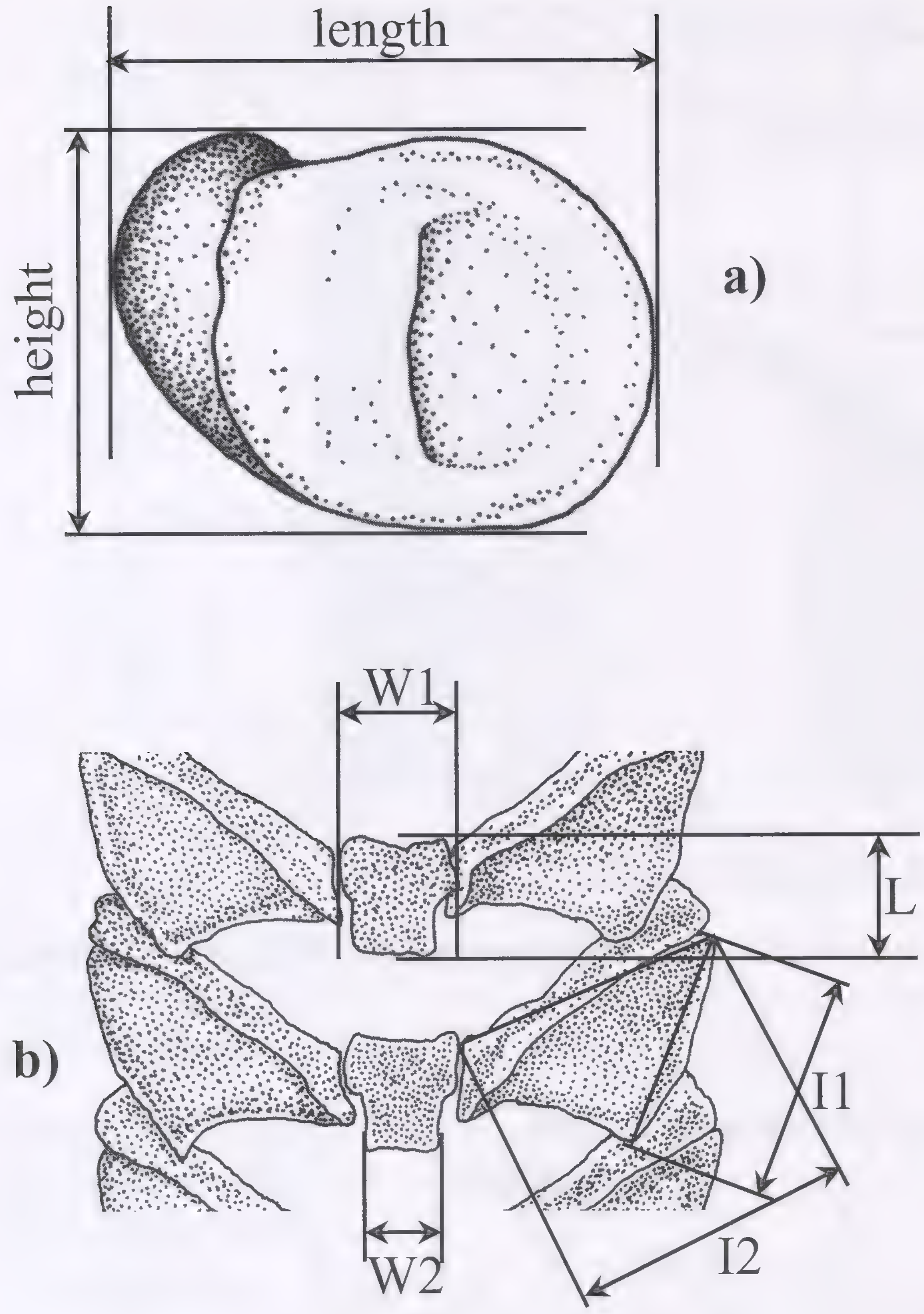

Figure 2 **a)** Scheme for the measurements of the shell length and height. **b)** Part of the *Theodoxus* radula (central and the two large intermediary teeth). Measurements of different radula features are indicated. Following relations were calculated: L/W1 and L/W2 for the central tooth, Q=I2/I1 for the large intermediary tooth.

T. fluviatilis from brackish waters are distinguished from freshwater individuals by having different habitat preferences. We never observed the migration or colonization of brackish water animals into rivers or vice versa. Generally, we found a zone between both habitats which is not occupied by *Theodoxus*.

Individuals from freshwater occupy running waters or the littoral (lotic) zone of bigger lakes. These habitats are generally highly oxygenated. *Theodoxus* settles on hard substrata like stones, wood, and in some circumstances, on plants (*Phragmites australis*, *Nymphaea alba*, *Nuphar lutea*). In inner coastal waters and in nearshore waters off the coast (not deeper than 5-10 m) with moderate salinities (between 2 and 8 psu) *Theodoxus* mostly colonizes phytal substrata like *Fucus vesiculosus*, *Potamogeton* spp. or *Zostera marina*. We observed a maximum abundance between 200 and 1000 ind./m^2 in the boddens (shallow and sheltered coastal water of the southern Baltic with oligo- and mesohaline conditions) of Darss-Zingst. In more saline regions (10-20 psu) the species prefers hard substrata. In deeper areas (below 15 m and without plants) stones, boulders and sometimes *Mytilus*-aggregates are good habitats for *Theodoxus* as well. At the Adlergrund/Rönnebank, a shallow and stony area between the islands of Bornholm and Rugia, we found an abundance around 200 ind./m^2 in September 1999 and May 2002.

MORPHOLOGICAL FEATURES

Regarding periostracum coloration *T. fluviatilis* is a highly variable species (Fig. 6, 7). In the outer coastal waters of the Baltic Sea the nearly black and often corroded form of shell is predominant (Fig. 6a, b) whereas in the inner (sheltered) parts of the coastal waters the yellowish-green form prevails (Fig. 6g-n). Marked differences exist among the freshwater populations as well. The background colour may be pale or the whole shell may be dark. The shell is ornamented with a pattern of yellow-white streaks (Fig. 7a, b), netlike structures (Fig. 7d, e) or dots (Fig. 7g-n). Excluding the largest individuals, the regressions between shell length and shell height of both freshwater and brackish water populations were very similar (Fig. 3). The difference between them is not significant. *T. fluviatilis* from brackish water habitats grew to a length of up to 9.3 mm and a height

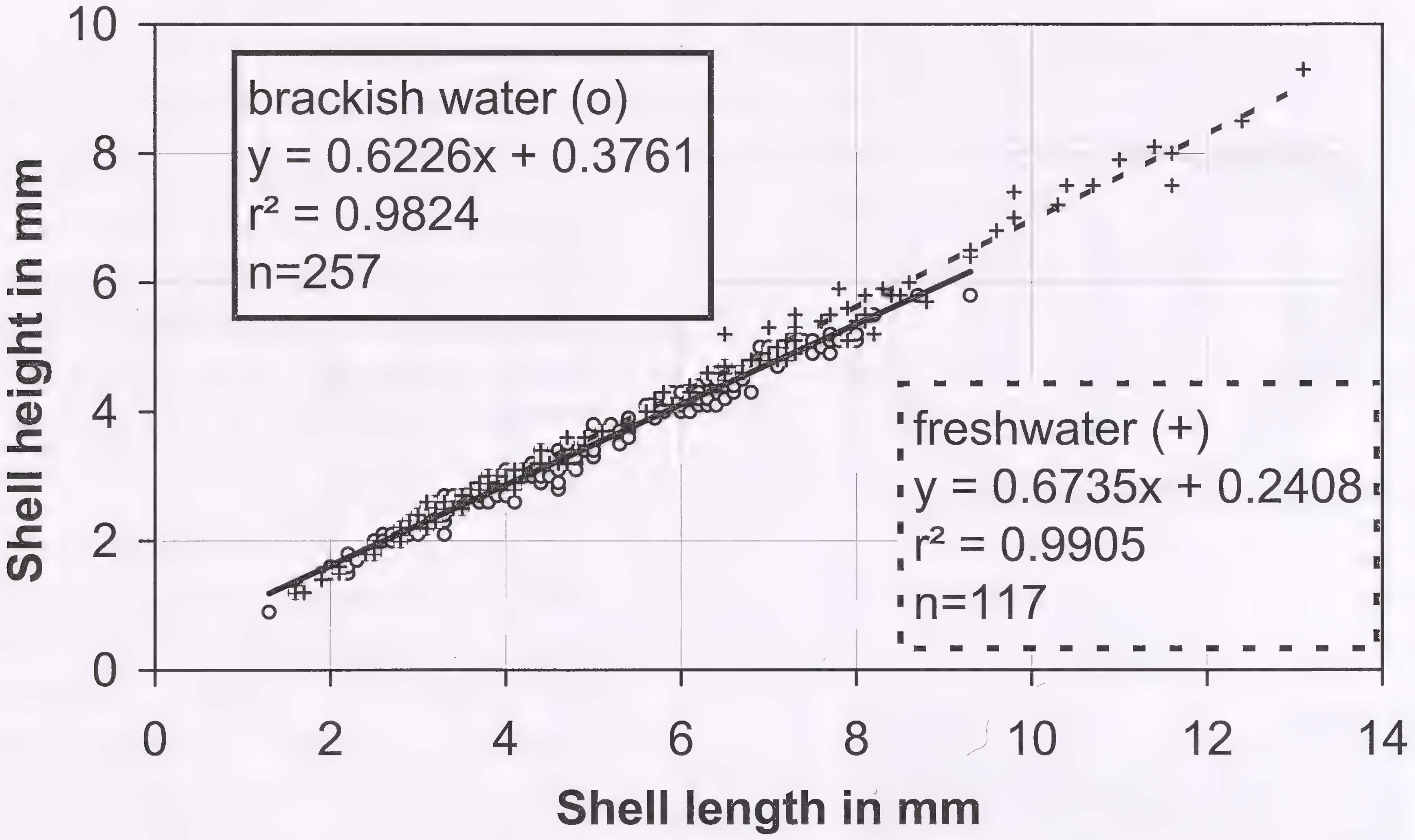

Figure 3 The regression line for shell length and shell height of *Theodoxus fluviatilis* from brackish and freshwater populations.

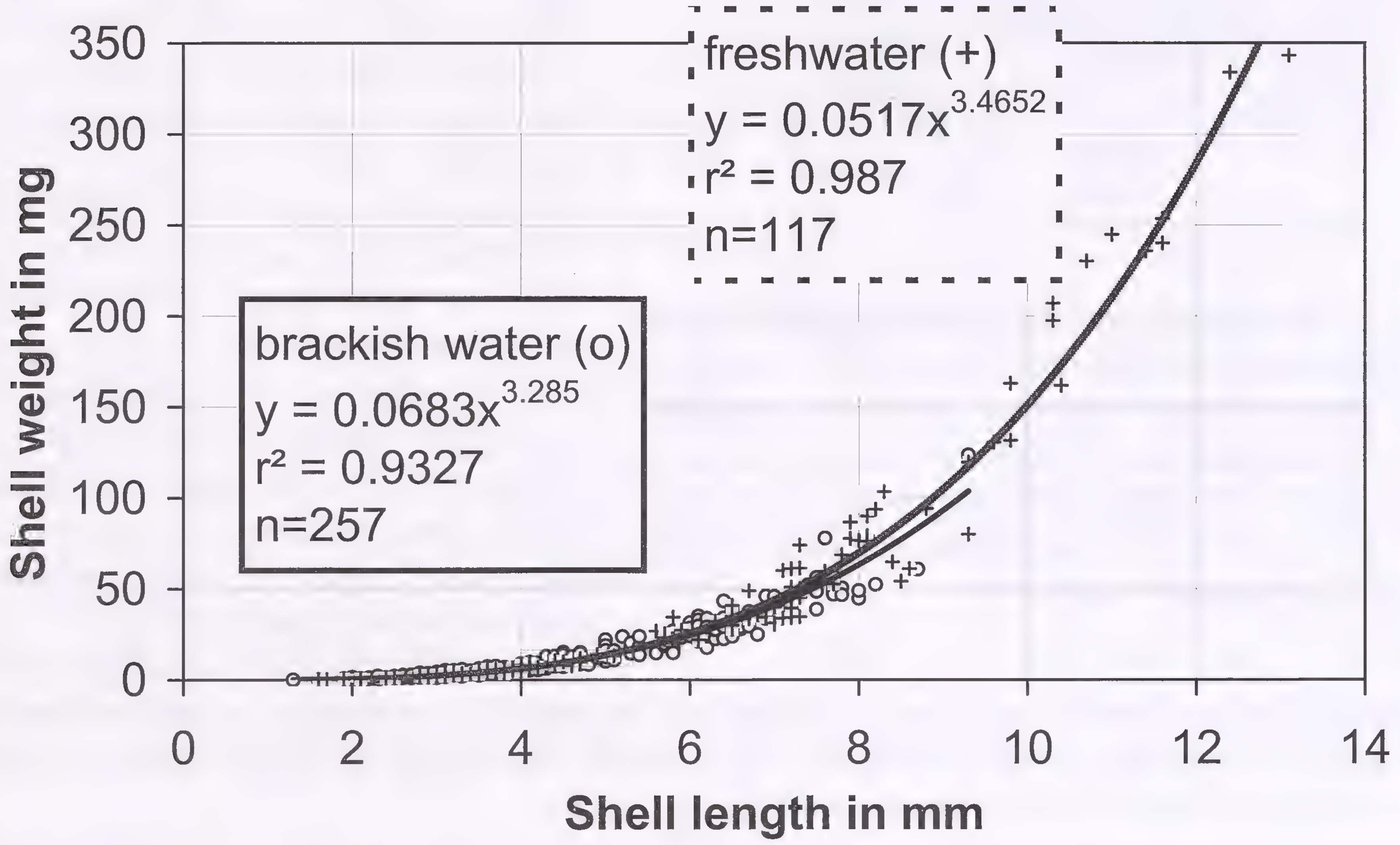

Figure 4 The regression line for shell length and shell weight of *Theodoxus fluviatilis* from brackish and freshwater populations.

of 5.8 mm. The maximum shell length of freshwater populations was 13.1 mm and the height reached was 9.3 mm. Also, the relations between shell length and shell weight are very similar across habitats (Fig. 4). We found no significant difference. Our data show that there is no change in the relationship between shell length and weight across the entire range of sizes. The maximum shell weight of brackish water *Theodoxus* was 124 mg whereas the shells of freshwater specimens weighed 343 mg at the most.

Regarding the radula measurements both the relations within the single central tooth (L/W1 and L/W2) and the large intermediary teeth (Q) showed no significant differences between *T. fluviatilis* from brackish water or freshwater habitats (Fig. 5). Even

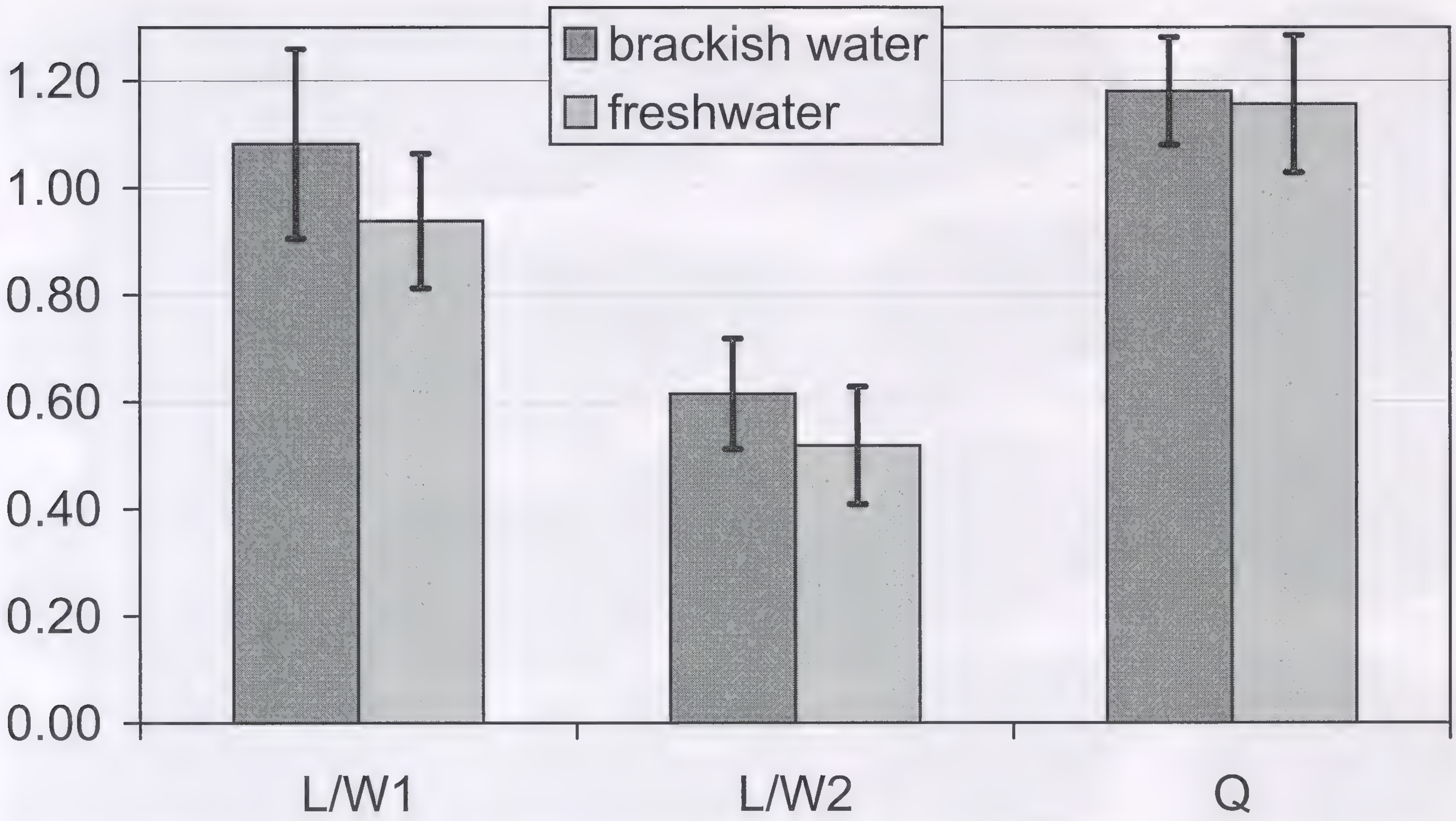

Figure 5 The relation between different radula features of the central tooth (L/W1, L/W2) and of the large intermediary tooth (Q) of *Theodoxus fluviatilis* from brackish and freshwater populations. The measurement of these parameters are shown in figure 2.

when the substrata (stones or plants) of the populations (see Table 1) were taken into account (not shown in figure), we never found characteristic features to justify separate radula shapes.

Microscopic inspection of the opercula revealed no differences between brackish water and freshwater individuals (Fig. 6, 7). The operculum is equipped with a ridge on the inner side, supporting the attachment of the columellar muscle. Usually in *T. fluviatilis,* there is no knob on the opercular hinge.

DISCUSSION

Considering coloration, *T. fluviatilis* is a variable species both in brackish water and freshwater habitats. The colour and the patterns of the periostracum are influenced by external factors like ionic composition of the milieu and possibly by the substratum and/or nutrition (Rotarides, 1932; Jaeckel, 1952; Neumann, 1959; Heller, 1979; Dillon, 2000). In the outer coastal waters of the Baltic Sea, the nearly black and often corroded form of shell is predominant, whereas in the inner parts of the coastal waters mainly the yellowish-green form prevails. Both forms are indicative of different substrata. The animals from lotic areas with stony substrata are more black. On soft bottom and in more sheltered areas *T. fluviatilis* is confined to vegetation like *Zostera*, *Potamogeton* and *Fucus*. In these areas the more yellowish-green and transparent shells dominate. This indicates the likely influence of habitats/substrata on shell colour variability. We report some differences between *T. fluviatilis* from brackish and freshwater habitats: The mean size of the shells in brackish water habitats is smaller than in freshwater (Glöer, 2002). In a brackish water population near Askö (near the same locality as our station 1) Skoog (1971) found a maximum shell length of 8.5 mm. *T. fluviatilis* from the brackish Lochs of Harray and Stennes (Scotland) reached a shell length between 6.5 and 9 mm (Nicol, 1938). During the cruise of Knipowitsch (1909) several hundred specimens were collected. The maximum shell length was 9.6 mm from the locality of Ytternäs

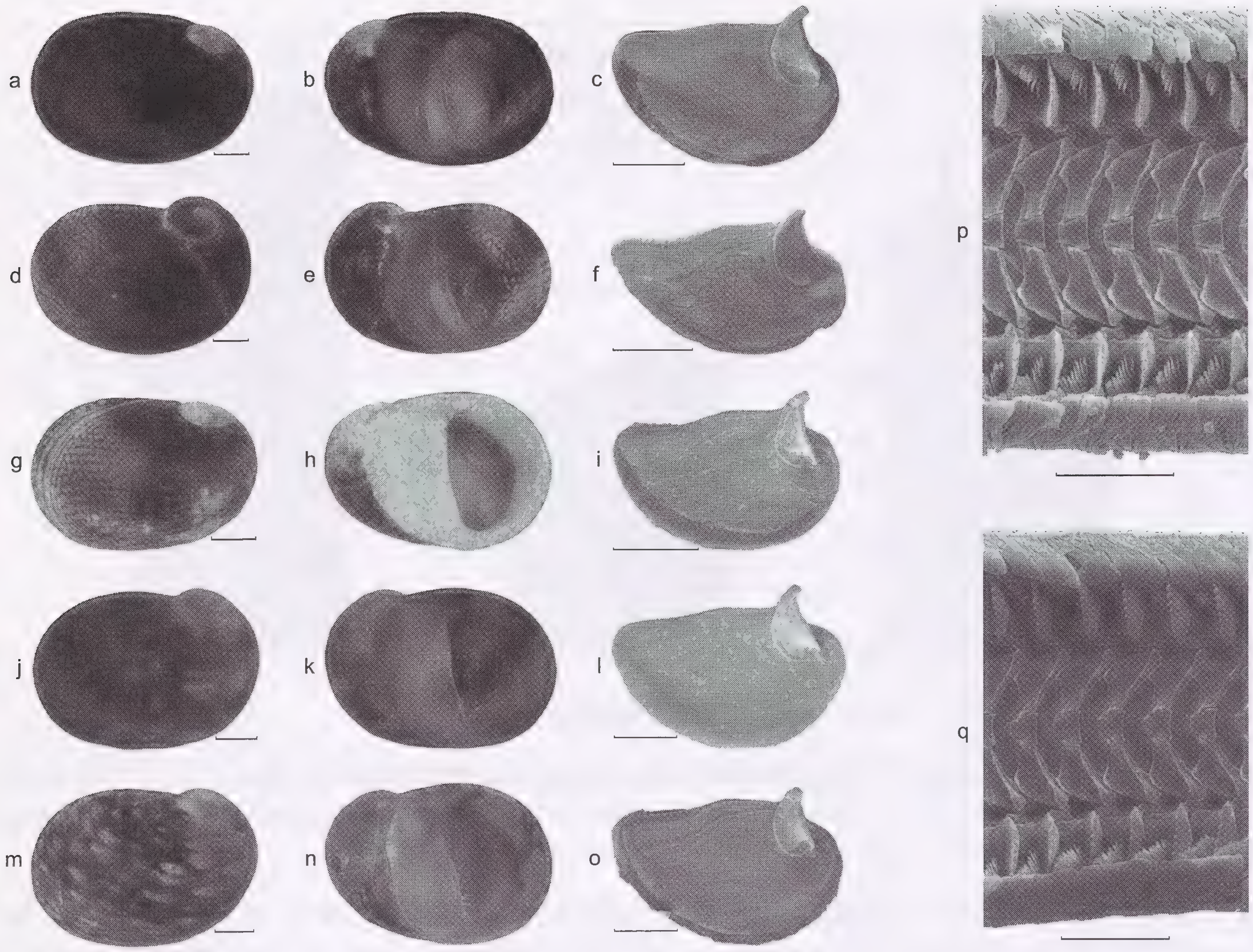

Figure 6 *Theodoxus fluviatilis* from different brackish water locations (see Table 1 for more information). **a-c)** Askö, Sweden, **d-f)** Tvärminne, Finland, **g-i+q)** Puck Bay, Poland, **j-l+p)** Barther Bodden, Germany, **m-o)** Greifswalder Bodden, Germany. The scale bar is always 1000 µm except for the radula which is 100 µm.

(Mariehamn) on Åland (Finland). The upper shell length in our study of brackish water specimens was 9.3 mm (Greifswalder Bodden). The maximum shell length of *T. fluviatilis* in freshwater was 13.1 mm (River Randow) which is in the upper range of this species (e.g. Falniowski, 1989; Glöer, 2002).

In brackish water the size of the egg capsules is smaller and the number of eggs within each capsule is lower (about 40%) (Bondesen, 1940; Graham, 1988). Further differences occur with respect to their behaviour. *T. fluviatilis* in freshwater is restricted (with some exceptions; *Phragmites australis*, *Nymphaea alba* and *Nuphar lutea*) to hard substrata, scraping food with its radula (Bandel, 2001). For example stones offer a counterpart for the radula when the animal is grazing on diatoms (Ulrich & Neumann, 1956; Neumann, 1961; Carlsson, 2000; Zettler, 2000). In the laboratory it was possible to keep the animals on plants for a restricted time only (Neumann, 1961). Carlsson (2000) found *T. fluviatilis* in one lake on the Åland Islands under the leaves of water lilies (*Nuphar lutea*), which may be explained by the fact that the plants are offering the same kind of substratum as stands of bladder-wrack (*Fucus vesiculosus*) and eelgrass (*Zostera marina*) on which it is often found in the Baltic Sea (Boström & Bonsdorff, 1997; Malm *et al.*, 1999; this study). These findings may indicate that there are differences in the construction of the radula of *Theodoxus* from both habitats (brackish water or freshwater, stones or phytal). No evidence for this hypothesis was found in the present study. The radular features (central and intermediary teeth measurements) showed no significant differences between brackish and freshwater specimens and between individuals from stony or phytal substrata.

Some investigations have been made on the adaptability of *T. fluviatilis* from

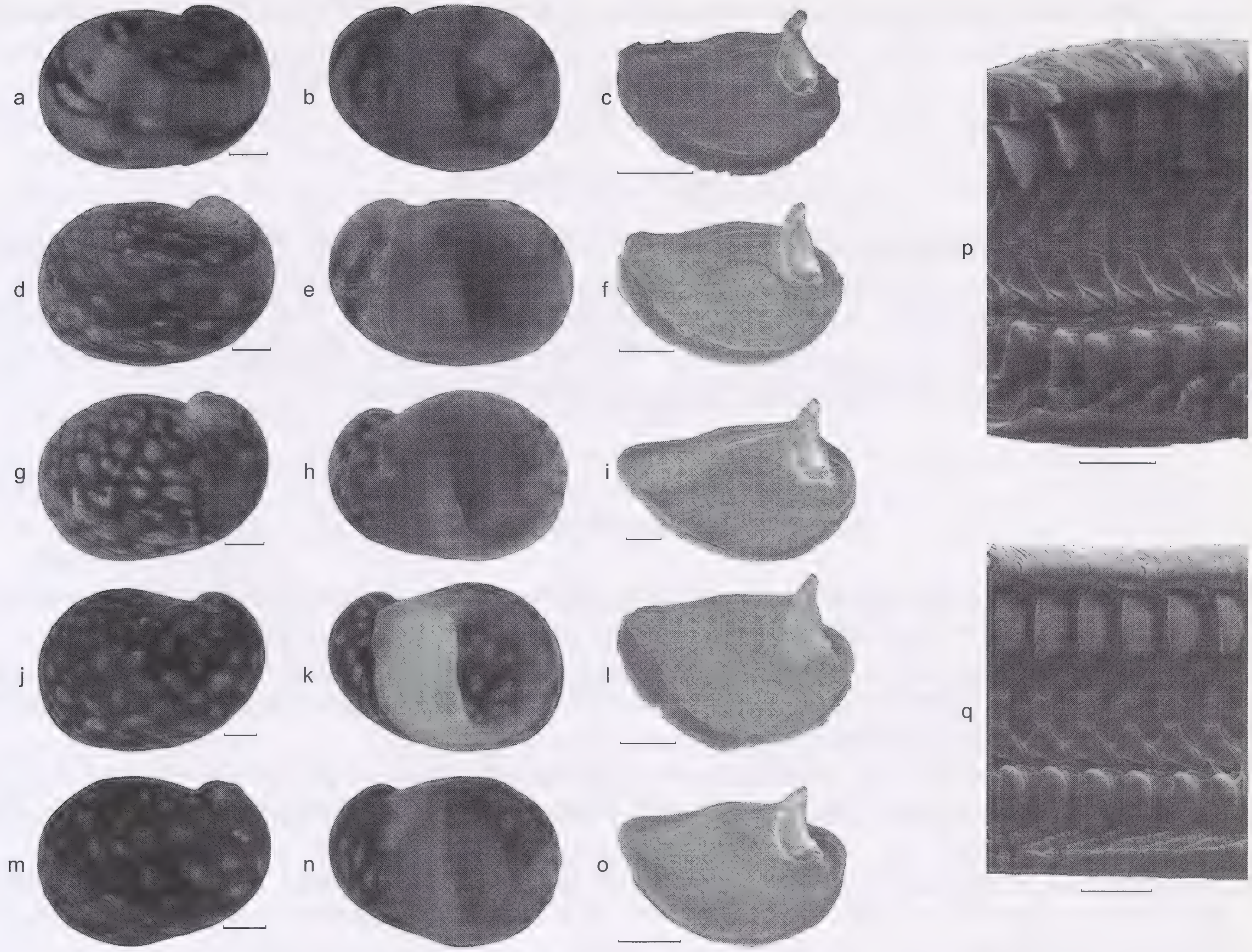

Figure 7 *Theodoxus fluviatilis* from different freshwater locations (see Table 1 for more informations). **a-c)** Bresenitz, Germany, **d-f+p)** Mühlengeezer See, Germany, **g-i)** Schaalsee, Germany, **j-l)** Randow, Germany, **m-o+q)** Rudower See, Germany. The scale bar is always 1000 µm except for the radula which is 100 µm.

brackish and freshwater habitats. Investigations of the salinity tolerance of individuals from different salinity regimes revealed differences between populations which are correlated to their origin (Kangas & Skoog, 1978; Neumann, 1960). Individuals from brackish water and freshwater populations were investigated by Neumann (1960) to assess their physiological adaptability by slowly and rapidly changing the salinity. He found a correlation between an animal's origin and its salinity tolerance. The brackish water individuals tolerate higher salinities than those from freshwater. A similar result was obtained for three populations from the northern Baltic Sea and one population from a Swedish freshwater lake (Kangas & Skoog, 1978). They found that freshwater animals were much less tolerant of salinity changes than brackish ones, and the brackish individuals vary in their ability to tolerate changes with respect to the degree of salinity in their original habitat.

Regarding morphology (shell size, operculum, radula), we found no significant differences between brackish water and freshwater populations of *T. fluviatilis* in the Baltic Sea area. The variability of shell morphology and ecological behaviour of *T. fluviatilis* within and/or between brackish water and freshwater populations demonstrates the large ecological and morphological variation within this one species. It would be of further interest to investigate populations from brackish waters and freshwaters with respect to genetic differences to obtain further knowledge regarding the species status of *Theodoxus* in the Baltic area. Some results indicate no differences between speciemens from fresh and brackish environments (Nyman & Skoog 1977, P.

Bunje, pers. comm.). According to our results, maintenance of *T. fluviatilis* as one species is justified.

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PSEUDOTRICHIA RUBIGINOSA (PULMONATA, HYGROMIINAE): A SNAIL NEW TO FRANCE

X. CUCHERAT & S. DEMUYNCK[1]

Abstract Pseudotrichia rubiginosa *is recorded for the first time in the North of France in July 2001 in the valley of the Lys river. Its habitat and malacological community are described. The results are compared with the available ecological data on this species in Western Europe.*

Key words Pseudotrichia rubiginosa, *Lys river, France.*

INTRODUCTION

The first record of *Pseudotrichia rubiginosa* (Rossmässler, 1838), made by Clanzig (1987), in the Mont Pilat (Loire), was recently disproved by Falkner, Ripken & Falkner (2002) in their checklist of the non-marine molluscs of France. These authors contested the presence of this species in a mountain context since *Pseudotrichia rubiginosa* had only been reported from flooded river plains. This snail lives in wetlands in the flood zone of freshwater rivers. The habitat is characterized by areas of bare mud, covered with an important layer of litter and by a sparse community of tall herbs often including nitrophilous plants species (Obrdlik, Falkner & Castella, 1995; Killeen, 1999).

Pseudotrichia rubiginosa is an East-European species (Kerney, Cameron & Bertrand, 1999), which is listed in the British Red Data Book (Bratton, 1991) under Category RDB2, Vulnerable, and is also listed in the German Red List (Falkner, 1990). In the western part of its distribution range, *Pseudotrichia rubiginosa* is present in Belgium in the Scheldt valley and its tributaries (Vader, 1977; De Wilde, Marquet & Van Goethem, 1986; Van Goethem, 1988) and in Britain in the Thames valley (Naggs, 1983; Killeen, 1999). Given this geographical distribution, it was considered that surveys for the species in northern France were merited.

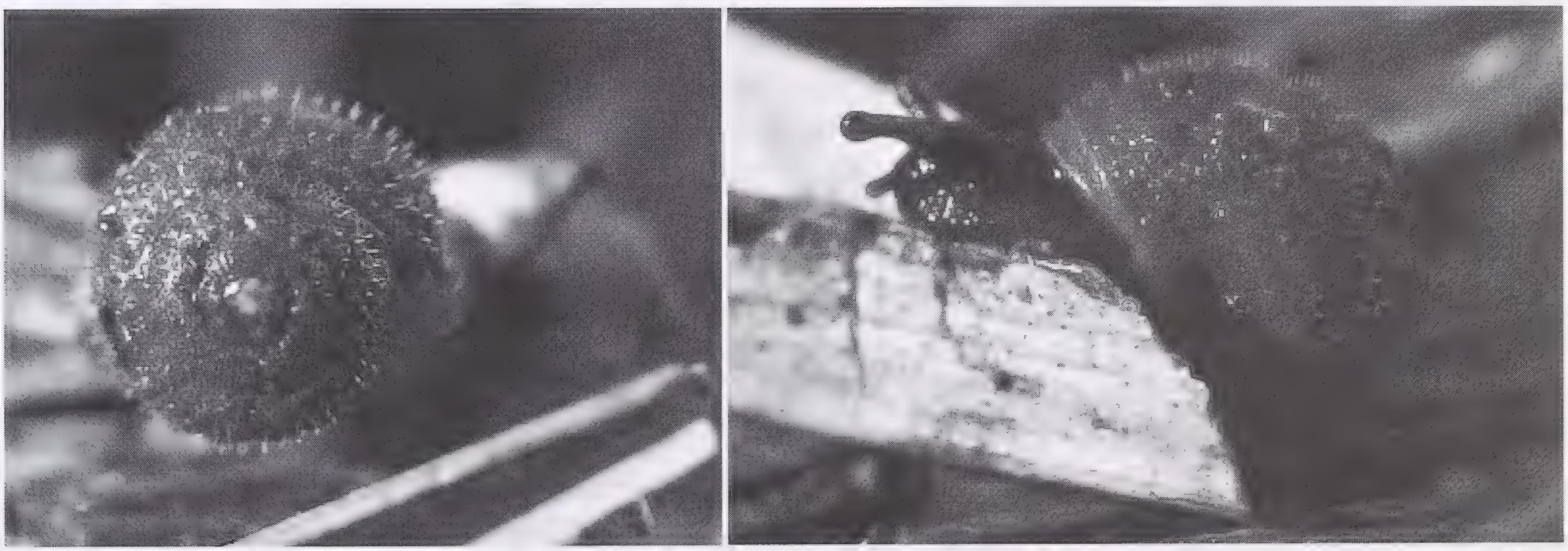

Figure 1 a-b Living specimen of *Pseudotrichia rubiginosa* from Nieppe, River Lys (Actual shell diameter 6 mm).

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[1] Université des Sciences et Technologies de Lille, Laboratoire d'Ecologie Numérique et d'Ecotoxicologie. FR CNRS 1818. Bât. SN3, F-59655 Villeneuve d'Ascq Cedex. xavier.cucherat@wanadoo.fr

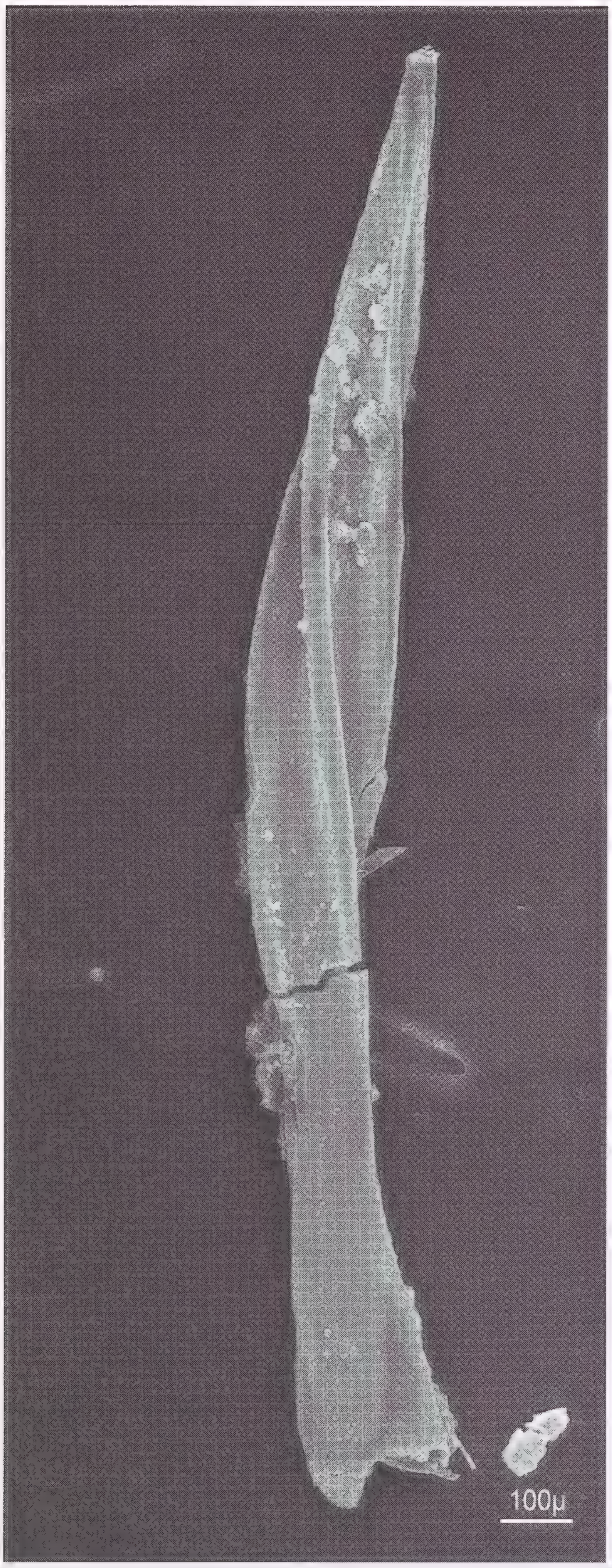

Figure 2 *Pseudotrichia rubiginosa* dart from Nieppe, River Lys (scale bar 100 µm).

DESCRIPTION

EXTERNAL FEATURES

The following description of *Pseudotrichia rubiginosa* has been compiled from the accounts of Falkner (1990) and Kerney *et al.* (1999).

The shell is globular with a convex spire, 4 ½-5 slightly tumid whorls separated by shallow sutures. The last whorl is not angulated at the periphery. The aperture, without internal rib, is rounded with a non-complete peristome. Lip is sharp and reflected over columella, leaving a narrow umbilicus. The shell is red-brown, thin, translucent and moderately glossy. The periostracum is densely haired with short and moderately bent hairs at their extremity. When the shell is old, hairs are often absent.

The head, the tentacles and the back of the animal are grey-anthracite; the foot and lateral parts of the body are whitish-grey. The mantelcollar is a pinky-red colour (see Fig. 1 a-b).

INTERNAL FEATURES

The male part of genitalia is composed of long and thin penis sheath and epiphallus. The flagellum is also long and thin (flagellum is about ½ penis sheath plus epiphallus). The vagina possesses a lateral and long dart sac. The dart is curved and twisted (see Fig. 2). There are two pairs of mucus glands, which are long and narrow.

LOCATION AND DESCRIPTION OF THE STATION

Pseudotrichia rubiginosa was discovered in July 2001 in the Lys valley (tributaries of the Scheldt river), in the municipality of Nieppe (Nord; DS 81), 20 km W of Lille.

The site comprises about a 100 m length of the Lys river, between a meadow and an open field. The site is adjacent to a ditch which separates it from the meadow. This ditch periodically floods the site. The floristic assemblage is given in Table 1. This assemblage shows that the station is occupied by a tall herb community dominated by the sedge *Carex riparia* (spatial extension comprised between 50 and 75% of the total surface) changing to a sedge fen (De Foucault, personal communication). The other plants species are all associated with wetlands. The other species of molluscs collected with *Pseudotrichia rubiginosa* are given in Table 2. It can be seen that nine species are hygrophilous land snails but three of them were recorded only as very old shells. The occurrence of two freshwater snails (*Galba truncatula* and *Anisus cf. spirorbis*), found as empty shells, indicates that the site is sometimes flooded by the ditch.

TABLE 1

The floristic assemblage of the station containing the land snail *Pseudotrichia rubiginosa*

Plant species	**Spatial extension in %**
Caltha palustris L.	10-25
Calystegia sepium (L.) R. Brown.	10-25
Carex riparia Curt.	50-75
Equisetum palustre L.	0-10
Filipendula ulmaria (L.) Maxim.	25-50
Phragmites australis (Cav.) Stend.	25-50
Symphytum officinale L.	10-25

TABLE 2

List of the molluscs associated with *Pseudotrichia rubiginosa* at the site of Nieppe

Species	**State**
Galba truncatula (O.F Müller 1774)	Dead shells
Anisus cf. spirorbis (Rossmässler, 1835)	Dead shells
Carychium minimum O.F Müller 1774	Living
Succinella oblonga (Draparnaud, 1801)	Sub fossil
Succinea putris (Linnaeus, 1758)	Living
Cochlicopa sp.	Living
Vallonia pulchella (O.F Müller 1774)	Sub fossil
Vertigo pygmaea (Draparnaud, 1801)	Living
Vitrea crystallina (O.F Müller 1774)	Living
Nesovitrea hammonis (Ström, 1765)	Sub fossil
Deroceras laeve (O.F Müller 1774)	Living

DISCUSSION

Pseudotrichia rubiginosa is also known as *Perforatella rubiginosa* (e.g. Killeen, 1999). In accordance with Falkner (1993) and the Check-list of the Continental European Mollusca (CLECOM) (Falkner, Bank & Von Proschwitz, 2001), we prefer to use *Pseudotrichia rubiginosa*.

This is the first time that *Pseudotrichia rubiginosa* has been recorded in France, and in a similar habitat as those previously described from Western Europe (Vader, 1977; Killeen, 1999). In fact, the station of Nieppe shares a lot of common features with the sites of the region of the Scheldt estuary in Belgium described by Vader (1977) or those in the Thames valley described by Killeen (1999). These features are: the temporary presence of the water, the importance of decaying organic rich litter, the muddy consistency of the sediment and the presence of nitrophilous plant species.

The occurrence of dead shells of freshwater gastropods proves that the place is often flooded by the ditch, although the Nieppe station is not a freshwater tidal flat as it is the case for most sites where *Pseudotrichia rubiginosa* occurs in Western Europe (Vader, 1977; Killeen, 1999). In addition, the soil seems to retain a high percentage of humidity since most of the species found together with *Pseudotrichia rubiginosa* are hygrophilous land snails.

The litter is produced *in situ*, unlike in the Thames valley (Killeen, 1999) or in the Scheldt valley (Vader, 1977) where it comprises flood debris deposited by rivers. This litter is mainly composed of leaves of *Carex riparia* and *Phragmites australis*. Finally, the plant community although dominated by *Carex riparia* contains nitrophilous species ones such as *Symphytum officinale*.

To conclude, the uncommon place of this record, next to a ditch, allows us to think that the main requirements of this snail are the soil humidity level and the amount of organic matter. Additional studies are now in progress to investigate this hypothesis.

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PSEUDOSUCCINEA COLUMELLA (SAY) AND OTHER ADDITIONS TO THE FAUNA OF MENORCA

The reviews of Gasull[1-4], Jaeckel & Plate[5] and Gasull & Altena[6] list 48 terrestrial and 15 fresh or brackish-water species in the fauna of Menorca, Balearic Islands.

During a visit in July 2002, some additional species, mostly non-native, were recorded. Two specimens of the North American freshwater 'slum' species *Pseudosuccinea columella* (Say), were taken in the Barranco de Algendar, near the outflow of its perennial stream to the sea at Cala Santa Galdana. The stream here is clear and unpolluted but slightly salinated through proximity to the sea. *Potamopyrgus antipodarum* (Gray), was abundant on rocks down to the outflow. *Lymnaea palustris* agg., *Radix peregra* (Müller) and *Ferrissia wautieri* (Mirolli) were found sparingly on marginal vegetation in areas of reduced flow inland. A specimen of *Lymnaea palustris* agg. from the site was dissected by Ron Carr and determined as the segregate species *L. (Stagnicola) fuscus* (C. Pfeiffer). This segregate is new to the Balearic Islands. *Pseudosuccinea columella* was reported from the Catalan coast in 1988[7] but has not been reported elsewhere in eastern Spain or the Balearic Islands until now. *Ferrissia wautieri* and *Potamopyrgus antipodarum* are also known from Catalunya[8] but again have not been reported from the offshore islands.

Other probable introductions were found among the terrestrial fauna. *Oxychilus draparnaudi* (Beck) was abundant in hedgerows and woods along the valley at Santa Galdana, along with several half-grown *Deroceras panormitanum* (Less. & Poll.). Neither have previously been listed for Menorca. An unbanded, translucent mid-grey slug was found under stones in native *Quercus ilex* L. woods at Santa Galdana and at Cala San Estéban south of Mahón. External characters suggest a *Lehmannia* but it does not readily accord with any described species, except possibly *L. melitensis* (Less. & Poll.). Its identity is being investigated. *Lehmannia valentiana* (Fér.) is a common native species elsewhere in the Balearic Islands, but was not listed by Gasull[1-4] or by Altena and Gasull[6] for Menorca. On the present occasion it was found to be common, along with *Limacus flavus* (L.), in stony garigue in the vicinity of Ciutadella and Mahón on opposite ends of the island, and at several intermediate localities including Santa Galdana. The Menorcan form is suggestive of the lightly-banded form common on Mallorca.

My sincere thanks to Ron Carr for determining the specimen of *Lymnaea palustris* agg.

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Roy Anderson
Dept. of Agricultural & Environmental Science,
Queen's University,
Newforge Lane,
Belfast BT9 5PX, UK

ANOTHER BRITISH SITE FOR LIVING *LAURIA SEMPRONII*

Lauria sempronii (Charpentier, 1837) was first found in Britain as a post-Glacial fossil[1]. In 1971 live material, collected in 1894 at Haresfield Beacon (SO/8208) was recognised in Leeds City Museum , but subsequent searching in 1971 failed to re-find it at Haresfield[2] and as of October 2003 *L. sempronii* has still not been refound there. A second site for living *L. sempronii* was found in SO/90 in 1985[3]. This site was later identified as at Edgeworth[4]. The snail was last seen living here on 16 November 2002, but the site was only visited very briefly on 14 October 2003.

A new site for live *L. sempronii* was found in SO/80 on 6 October 2003 during survey work for the Gloucestershire Wildlife Trust. Three live specimens were found , in a brief search, attached singly on the bare underside of stones on the top of a lightly vegetated old, weathered, dry-stone limestone wall on a west facing slope at an approximate altitude of 170m. The wall is slightly sheltered by a slight dip in the hillside. On 27th October, in a non-exhaustive examination, 12 live full-grown specimens and 9 live juveniles were noted among dead leaves and humus at 3 spots along the top of about 15m of wall. The wall forms part of a boundary between a small paddock and an area of unimproved, slightly scrubby, limestone grassland. It is shaded by Hazel (*Corylus avellana*), Blackthorn (*Prunus spinosa*), Ash (*Fraxinus excelsior*), and a Durmast Oak (*Quercus petraea*). Other molluscs noted on the wall on 6th ,7th and 27th October were *Helicigona lapicida*, *Oxychilus alliarius*, *Clausilia bidentata*, *Pyramidula rupestris*, *Discus rotundatus*, a dead *Trichia striolata* and a dead juvenile *Helix pomatia*.

No *Lauria cylindracea* have so far been found with *L. sempronii* at the new locality, but *L. cylindracea* occurs separately on a continuation of the wall, after a 3m-wide gap for a gate. This stretch is more heavily shaded and overgrown than the *L. sempronii* site. On 27 October it was noted that the stretch of wall with *L. sempronii* caught the sun at around 1600GMT, whereas the rest of the wall did not.

Unlike the Edgeworth site there are no buildings within 500m nor are there possible rockery plants on the wall.

As at Edgeworth and Haresfield there is no parietal fold in the aperture of the shells.

I thank Dr Michael Kerney for verifying the identification of *L. sempronii* and reading this note in draft, the Gloucestershire Wildlife Trust for asking me to carry out the survey work, and David Haigh for first finding *L. cylindracea* on 27 October.

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David Long

TWO NEW RIVERS IN ENGLAND AND WALES FOR THE FINE-LINED PEA MUSSEL *PISIDIUM TENUILINEATUM* STELFOX

In Britain, the fine-lined pea mussel *Pisidium tenuilineatum* Stelfox, 1918 occurs principally in central southern England, with the western and northern limits represented by the River Monnow in Wales and the River Wharfe, Yorkshire, respectively (Kerney)[1] (Killeen & Williams)[2]. As a result of a perceived decline, *P. tenuilineatum* was included on the UK Biodiversity Action Plan (BAP) 'short-list' of Priority species[3]. To address the aims of the Species Action Plan, the Environment Agency (as lead partner for the species), English Nature and the Countryside Council for Wales have initiated and funded projects to provide up-to-date information on the species status, distribution and ecology. Two recent projects have led to the discovery of *P. tenuilineatum* populations in the River Usk in south Wales in August 2003, and the River Ure in Yorkshire in August 2002.

A total of 14 sites were sampled on the lowland section of the River Usk from Crickhowell downstream to the upper tidal limit at Newbridge-on-Usk. Specimens of *P. tenuilineatum* were found in 4 of the 6 samples taken from Chain Bridge (Grid Reference SO334053) to downstream of Usk town (ST386994). However, the species was rare; only 12 individuals were found at the four positive sites amongst a total of over 800 *Pisidium* specimens. The Usk was found to support five other *Pisidium* species: *P. nitidum, P. subtruncatum* and *P. casertanum* occurred at every sample site, *P. amnicum* occurred sporadically and a single specimen of *P. henslowanum* was recorded at the furthest downstream site at Newbridge-on-Usk.

Three rivers in Yorkshire: the Ure, Swale and Nidd, were surveyed to determine if *Pisidium tenuilineatum* was present elsewhere in the Dales (other than the R. Wharfe). Of these, the species was found only in the River Ure, and was restricted to a section between Wensley (Grid Reference SE093894) and Masham (SE225814). It occurred at 4 of the 11 sample sites and generally in very low numbers of individuals, although at a site upstream of Middleham Bridge it comprised approximately 30% of all individuals. Nine species of *Pisidium* were recorded in the Ure, but from Middleham Bridge to Boroughbridge, the fauna was generally very similar with few significant differences in the species composition from upstream to downstream.

As with several rivers in Britain, the populations of *Pisidium tenuilineatum* in both the Usk and the Ure appear to be restricted to a short length of each river and the species is usually present only in low numbers of individuals. A recent Environment Agency funded survey established very few definite correlations between the species' distribution and abundance with environmental factors (Killeen & Willing)[4]. *P. tenuilineatum* occurs in a wide range of flow conditions and sediment types. Whilst the species is regarded as a calciphile, sensitive to water pollution (Piechocki)[5], in Britain, at present, we have only limited information on the relationship between *P. tenuilineatum* distribution and water quality. However, data from the River Wharfe, Yorkshire and other rivers have shown that orthophosphate concentrations may be a limiting factor [2,4].

I gratefully acknowledge the funding from the Countryside Council for Wales for the River Usk survey, and the Environment Agency (Yorkshire Region) for the River Ure survey. Both agencies are thanked for their permission to disseminate the results.

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Ian Killeen
Malacological Services
163 High Road West
Felixstowe
Suffolk IP11 9BD UK
Email: ian@malacserv.demon.co.uk

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